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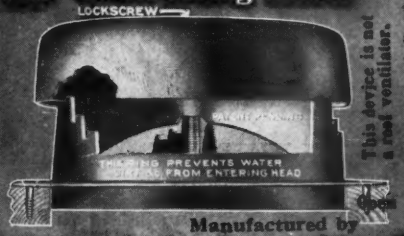

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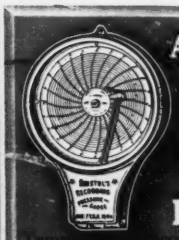

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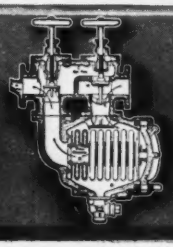

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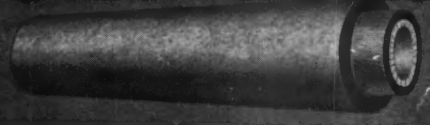

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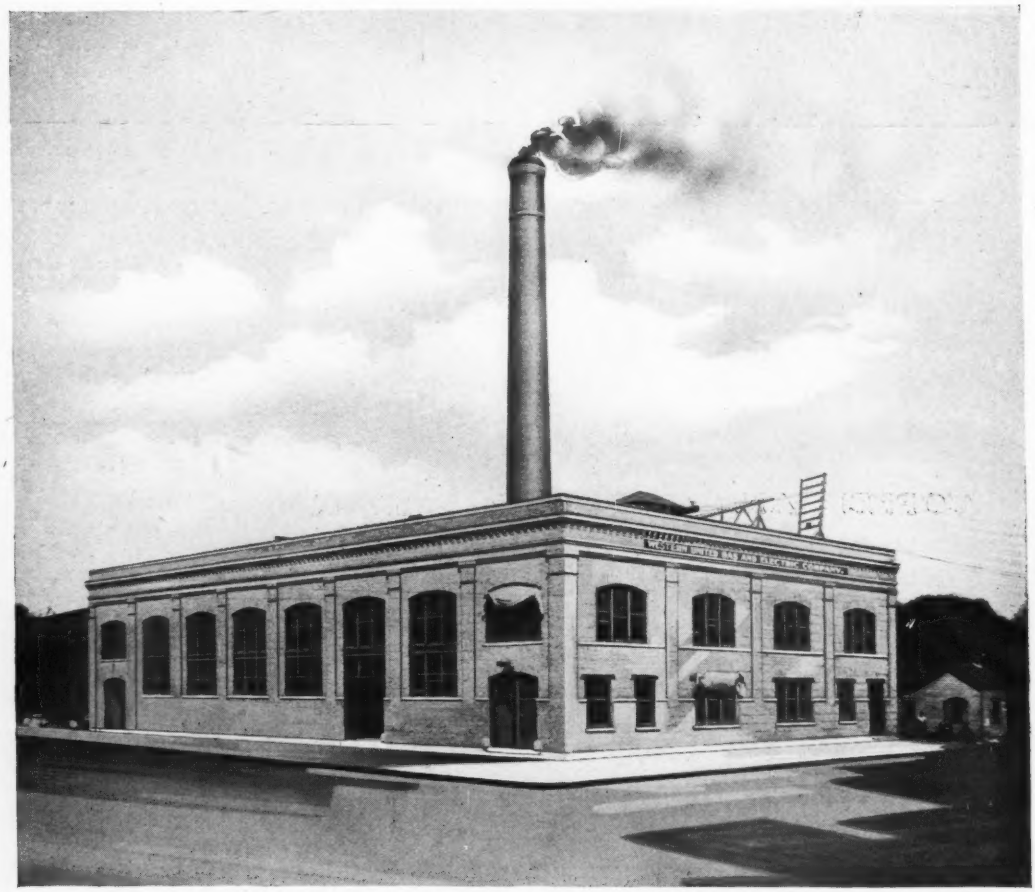

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Exhaust Steam as a Waste Product
vs.
Exhaust Steam as a Money Maker

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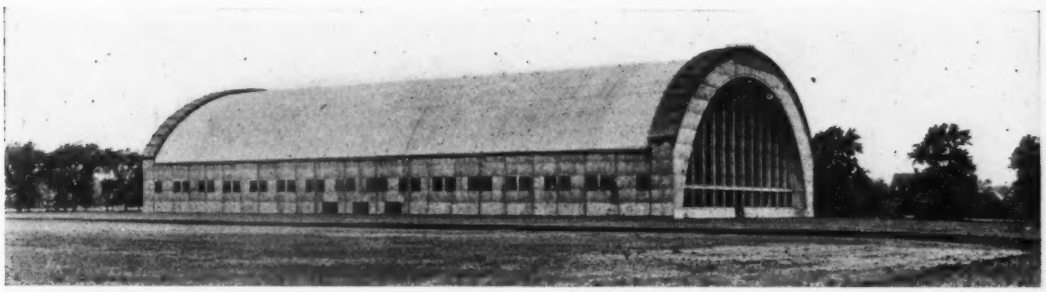
1123 BROADWAY NEW YORK SEPTEMBER, 1915



ARMORY BUILDING, UNIVERSITY OF ILLINOIS.

A Drill Room That Requires 23,000 Square Feet of Direct Radiation

PROBLEMS INVOLVED IN THE EQUIPMENT OF THE ARMORY BUILDING AT THE UNIVERSITY OF ILLINOIS.

BY GEORGE B. RICE.

At the time the problem of designing a heating system for the Drill Hall, at the University of Illinois, came up for consideration and definite decision, the room was one of the largest of its type in the country. Its principal dimensions are as follows:

Length	ft. 416
Width	ft. 212
Height to spring of segmental roof trusses	ft. 40
Height to top of roof trusses	ft. 95
Average height	ft. 81
Floor area	sq. ft. 88,000
Wall area, sides and ends	sq. ft. 46,200
Glass and door area, sides and ends	sq. ft. 21,200
Roor area	sq. ft. 105,000
Cubic contents	cu. ft. 7,101,325

The floor is of concrete except for an oval 340 ft. long and 140 ft. wide in the central portion, which is of sand and clay on a cinder foundation. This oval is of sufficient size for a seven-lap running track, its purpose being to permit the use of the building for general athletic sports.

The side walls are 8-in. hollow tile, plastered on the outside. These walls form a temporarv closure for the sides and in the completed building about 80% of them will be removed to provide passages and openings to rooms to be located in the two wings which will form part of the completed building.

The ends are all glass except for concrete pilasters, transoms and plastered arches. The area of glass for each end is 8,600 sq. ft. and of pilasters, etc., 8,000 sq. ft.

The main roof is of composition on 1-in. T & G sheathing. The roof for massive projecting cornices at each end is of copper on wood sheathing These

cornices and extension of same form open ways approximately 12 ft. square which are utilized as fan rooms, electric service rooms, toilets, stairways to the roof, and suction chambers for fans.

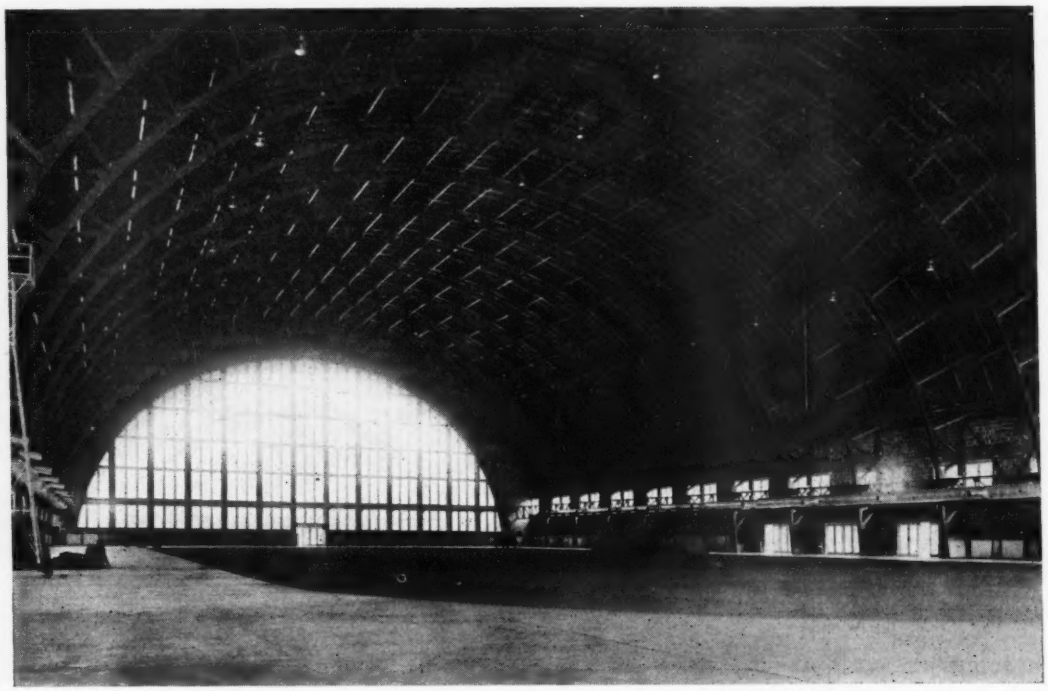
The main framing for this portion of the building consists of 16 three-pin arch trusses built up of Bethlehem sections.

HEATING SYSTEM.

In view of the conditions imposed, practically all suggestions that were received, either through invitation or otherwise for the design of the heating system, were rejected because, for the most part, they involved changes in the design of the completed building or marred the architectural characteristics of the main room.

Most of the suggestions received were for an all hot blast system, in combination with some direct radiation to take care of glass surfaces at the ends. These suggestions involved some 10,000 sq. ft. of heaters, in addition to the direct radiation, and fan capacity of about 150,000 c.f.m. to heat from 0° to 65° F. in one hour. A careful study of conditions should convince the advocates of this system that, while it is a splendid one, it cannot be installed in this building without incurring extraordinary expenditures for changes in the design of the steel work or for special fan houses, underground piping to same, underground ducts from the fans, and drainage for the ducts, or waterproofing for same.

As the accompanying figures indicate, the system installed has direct cast-iron water radiation as the main feature and two fans, each with 1168 lin. ft. of 1-in. pipe coil indirect. The purpose of the indirect is to take care of extreme weather conditions, or to be used in milder weather when the direct radiation for the sides of the building may be shut off, as well as to recirculate the air in the building.



GENERAL VIEW OF DRILL HALL, ARMORY BUILDING.

The steam flow mains enter the building from a manhole at the southeast corner, rise to a height of 14 ft. from the floor, divide into two 8-in. mains and extend around the ends and sides to the diagonally opposite corner, grading with the steam and reducing in size as the load is taken off. Anchors and double swing joints are placed approximately 100 ft. apart. For anchors the main is strapped to the steel work of the building, and

swing joints in straight runs are made up of two 45° and four 90° ells. The swing joints at three corners of the building are arranged to take the expansion of the two runs which are at right angles without disturbing the alignment of either run.

The return main is below grade, inside the building for the ends and outside for the sides, and is run in split tile.

The supplies to all groups of radiators are taken out of the bottom of the main and are dripped through thermostatic traps. These connections are at each truss, 26 ft. apart for the sides, and at each pilaster, 13 ft. apart for the ends. This reduces the accumulation of condensation in the mains and gives better quality of steam for the radiators.

The supplies are connected at the top of the radiators and returns at the bottom opposite the supplies. Returns are passed through a thermostatic trap for each radiator that is located on or near the floor and for each pair of radiators on columns or purlins above the flow main.

The connections from flow and return mains for the sides of the building are run in the channels of the steel trusses in order to conceal the work as much as possible. These connections at the ends of the building are kept near the pilasters in such a way that they are not objectionably conspicuous.

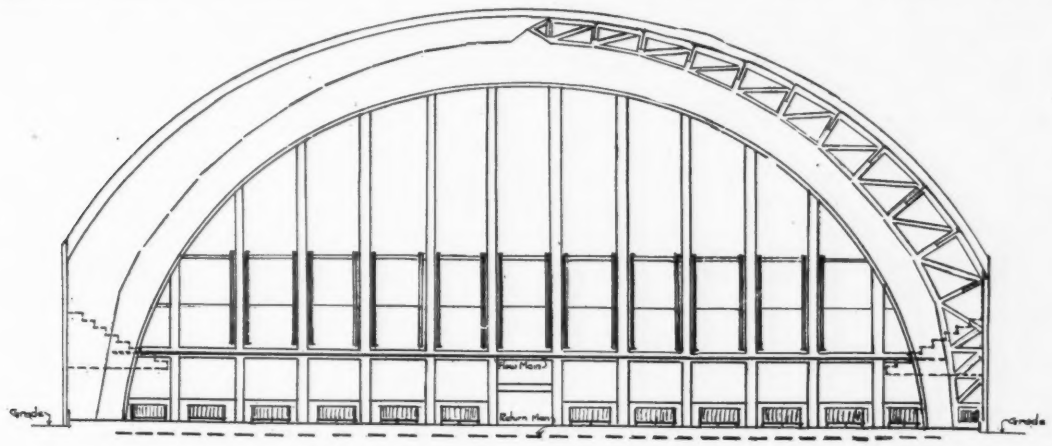
In all connections off the mains and to radiators, ample provisions have been made for expansion, both in the mains and in these connections.

There are 28 radiator units of 592 sq. ft. each for the sides, 24 units for the ends, averaging 294 sq. ft. for each unit, making a total of 23,632 sq. ft. of direct radiation.

For the sides of the building the radiators are supported on the trusses near the floor and on purlins approximately 40 ft. above the floor. For the ends, there is a line of radiators on the floor in each window bay and a second lot made up of ten 9B sections of American wall radiation connected end to end and placed alongside of the pilasters some 30 ft. above the floor. This arangement provides practically a continuous line of direct radiation along the walls and ends on or near the floor, the immediate effects of which will be felt by those in the building. The second line of radiators, on purlins and alongside of the pilasters is designed to intercept currents of cold air which follow down the underside of the roof and to take care of glass losses at the ends.

METHOD OF SUPPORTING RADIATORS ON SIDES OF BUILDING.

In the direct radiation the features of special note are the methods of supporting the units above the mains along the sides of the building. These are made up of 116 sq. ft. of 23-in. 2 column radiators suspended by means of "U" bolts from a line of 2½-in. extra heavy steel pipe resting directly on the steel work of the building. These lines of supports were ordered 22 ft. long and are connected by passing each end into a 3-in. pipe sleeve, 6 ft. long; this gives a lap of 12 in. at



END ELEVATION OF ARMORY BUILDING, SHOWING THE 144 SQ. FT. RADIATORS ON FLOOR AND 90 SQ. FT. RADIATORS ON COLUMNS.

each end, and the 3-in. sleeve is secured to the 2½-in. pipe by through bolts.

The wall sections placed alongside of pilasters at the ends of the building are secured by bolts to specially prepared foundations behind the plaster.

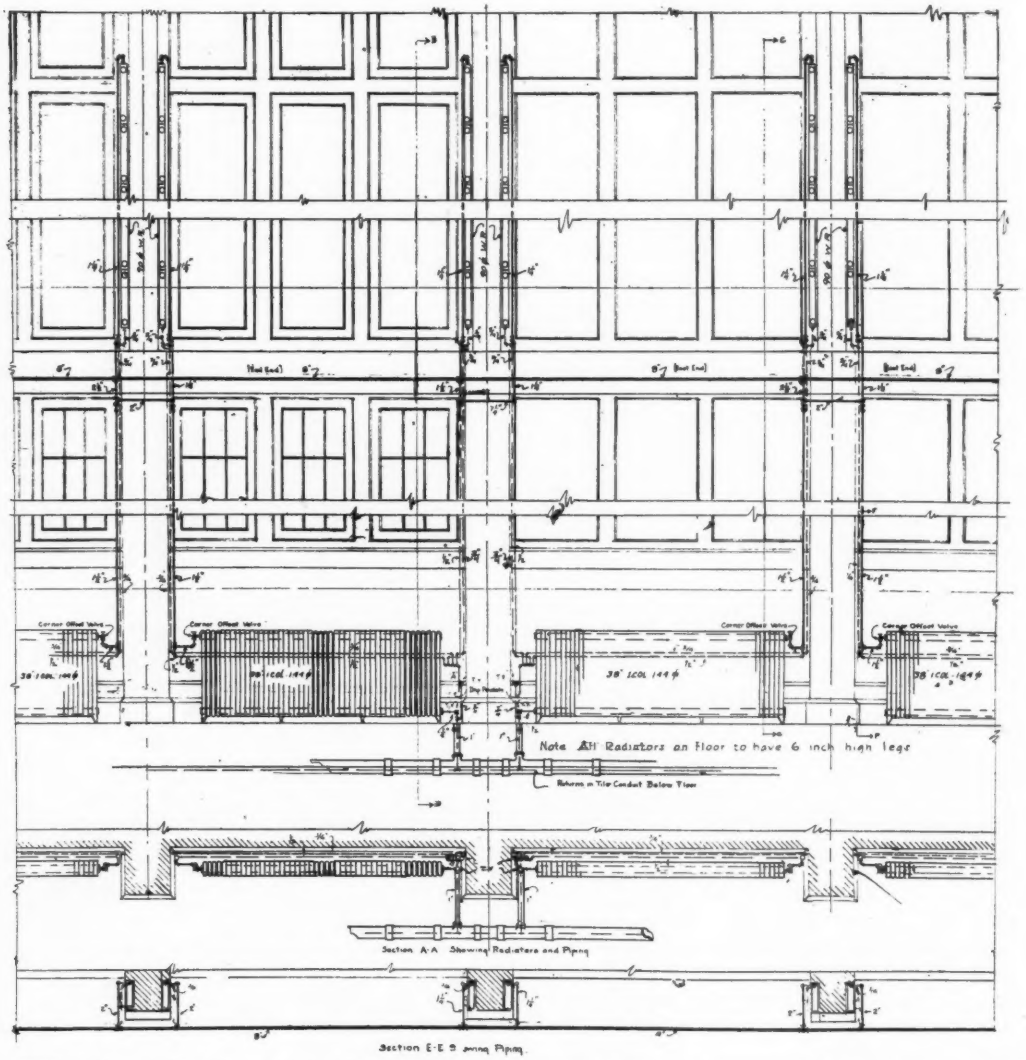
In the units for the different locations, the heights and number of columns were in each case selected to fill the entire space available, and at the same time have these units total the surface calculated for the entire building. This resulted in radiators 4 ft., 6 ft., 10 ft., and 12 ft. long. The units made up of 9-B wall sections are 24 ft. long, standing on end.

Each branch main is over 600 ft. long and the system operates very satisfactorily at 3 lbs. pressure without a pump.

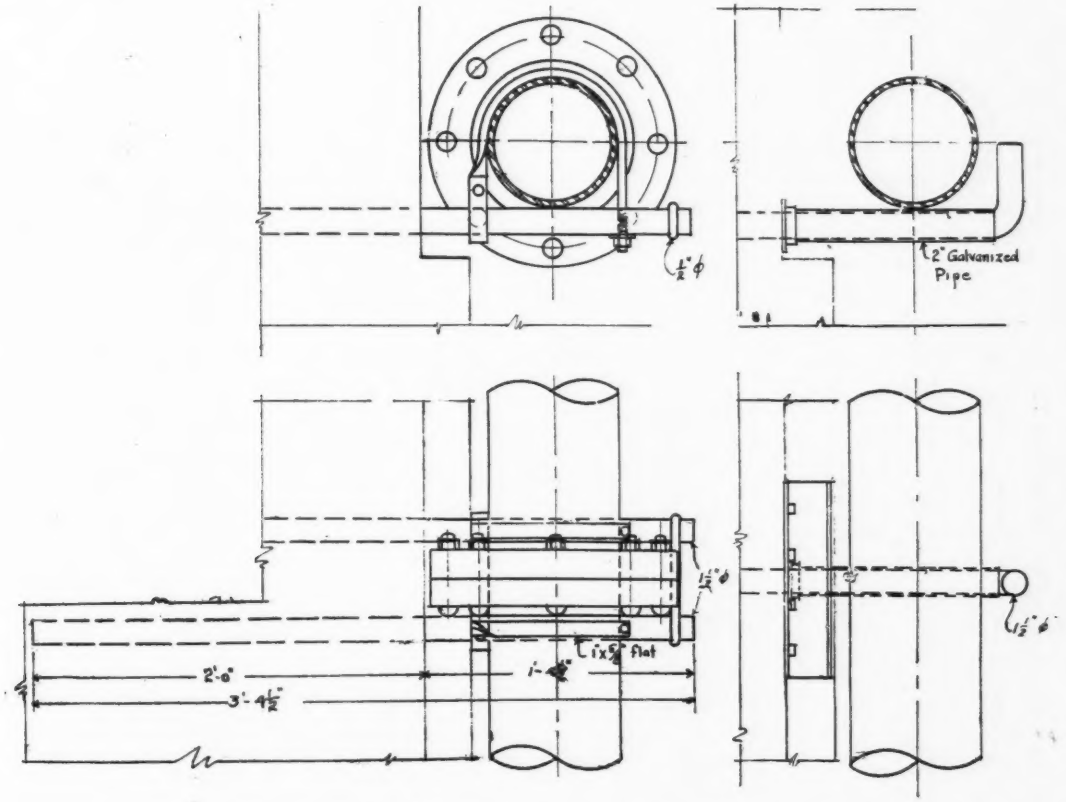
In the completed room, with balconies in place, all main piping and ducts and 90% of the drop pipes for the sides will be concealed. The balconies will conceal the main piping and ducts, and the drop pipes and branches off same are now concealed in the channels of the Bethlehem sections used in the trusses.

Calculations for Direct Cast-Iron Radiation.

The conditions to be met were: (1) to heat the building to a general temperature of 65° F. in zero weather, and it was not permitted to (2) interfere with any architectural features of the room nor (3) to locate the radiators elsewhere than on walls, columns, purlins and trusses.



TYPICAL DETAILS OF RADIATORS AND CONNECTIONS FOR EAST AND WEST ENDS, ARMORY BUILDING.



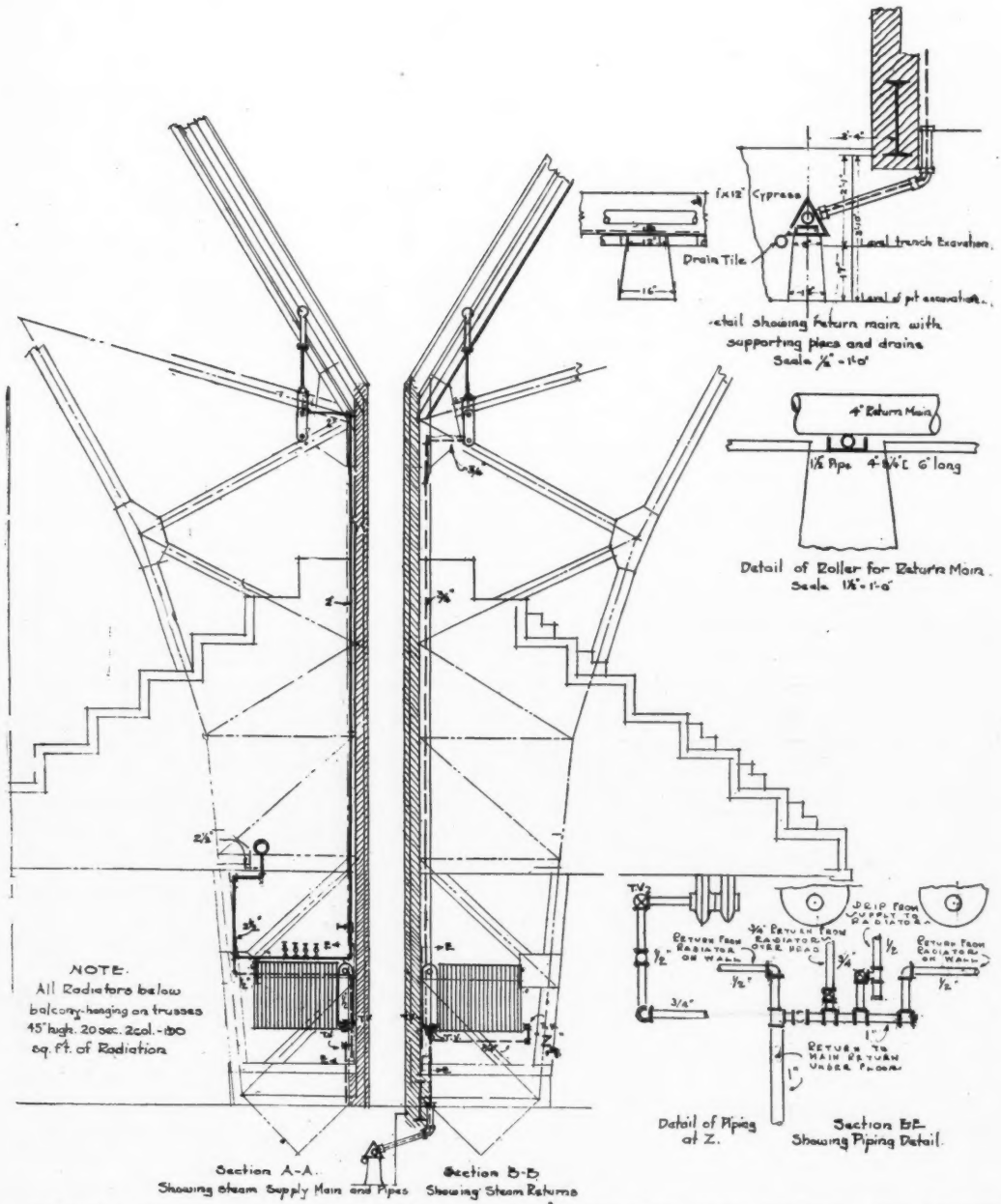
STEAM MAIN SUPPORT AND ANCHOR FOR EAST AND WEST ENDS.

To meet the first condition is a matter of installing *enough* surface, but the second placed limitations upon the first one, because there could be no special structure erected on which to place the units, and the dimensions of trusses, panels, columns, and purlins, were such that to respect the condition it was necessary to cover practically all available spaces with radiators of such dimensions that the radiating surfaces would be spread out as much as the spaces would permit, thereby resulting in a modified "hot-panel" arrangement. The third condition is a direct result of, and is demanded by the second one. Taking into consideration the fact that the units along the sides are practically 100 ft. from the center of the room, the necessity for depending upon convection currents is obvious. Temperature observations since the completion of the system, have shown a variation of less than 5° over the entire room at a plane 5 ft. from the floor and this small range is probably due largely to infiltration currents carrying the heated air across the room from the windward side. This fact was given due weight in determining the amount of surface required.

Also consideration was given the fact that the units could be so located that they would probably operate at very high efficiency and that while in standard practice, the time element for radiator efficiencies is based upon *one hour,* it is not always necessary to warm the room within this time, but a longer time may be assumed. In the present case the time element for direct radiation was assumed to be 90 minutes.

In figuring cubic contents, the room was conceived to be divided into spaces extending out to the edge of the balconies (yet to be constructed) and up to the roof in case of both the sides and the ends. The air in these spaces was figured to be heated from zero to 65° F. The main central zone of the building was figured to be heated through a range of 30° because it would be constantly tempered by convection or infiltration currents from the side spaces.

The wall and glass surfaces *below* bal-


1x12" Cypress
Drain Tile
Detail showing Return main with supporting piers and drains
Scale 1/4" = 1'-0"
4" Return Main
1 1/4 Pipe
Detail of Roller for Return Main
Scale 1 1/2" = 1'-0"
NOTE.
All Radiators below balcony hanging on trusses
45" high. 20 sec. 2 col. = 180 sq. ft. of Radiation
Section A-A.
Showing Steam Supply Main and Pipes
Section B-B
Showing Steam Returns
DRIP FROM SUPPLY TO RADIATOR
RETURN FROM RADIATOR OVER HEAD
RETURN FROM RADIATOR ON WALL
RETURN TO MAIN RETURN UNDER FLOOR
Detail of Piping at Z.
Section EE
Showing Piping Detail.

TYPICAL DETAILS OF RADIATORS AND CONNECTIONS FOR NORTH AND SOUTH SIDES, ARMORY BUILDING.

conies were figured for a range of 70° and these surfaces above the balconies for a range of 65°.

The floor temperature was assumed to be 40° and heated to 70° in all cases.

In case of the roof, the temperature of the inside surfaces was figured to be 5° on account of strong currents from radiation provided nearer the floor, and in case of the central portion, the lower temperature was figured to be 25° on account of the "pocketing" effect of heated air from below. The accuracy of this latter assumption may be considered questionable, but since the installation of the system, workmen have found it to be uncomfortably warm up near the roof.

The constants for losses through all surfaces were taken from Professors L. A. Harding, and Homer Woodbridge, and increased to take care of what was considered to be conditions more severe

than those on which their constants are based.

The B. T. U. transmitted per square foot of radiating surface per *hour* was assumed to be 300 for cubic contents for units near the floor and on columns at the ends, and 260 for all other units; on a 90 minute basis this would give 450 for the former and 390 for the latter.

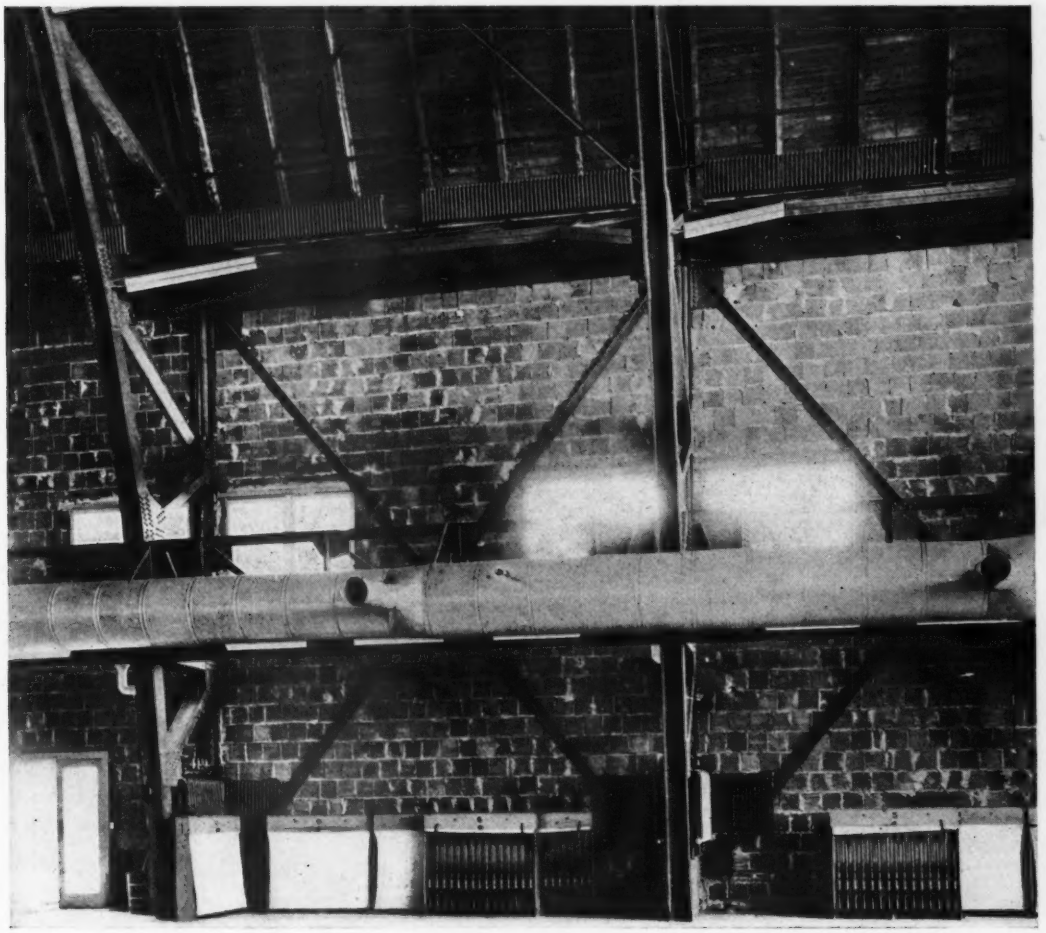
The following are the actual schedules, etc., as figured, "straight B. T. U. method" being used in all cases:

CUBIC CONTENTS.

Total cubic feet in entire building		7,101,325
North side, below balcony	141,400	
North side, above balcony	348,200	
South side, below balcony	141,400	
South side, above balcony	348,200	
	979,200	
East end, below balcony..	50,880	
East end, above balcony..	106,320	
West end, below balcony.	50,880	
West end, above balcony.	106,320	
	314,400	
Total		1,293,600
Contents of remaining central zone of building		5,807,725

GLASS SURFACES.

North side	1,972	
South side	1,972	
	3,944	
East end, below balcony.	1,632	
East end, above balcony..	7,000	
West end, below balcony.	1,632	
West end, above balcony.	7,000	
	17,264	
Total glass surface		21,208



INTERIOR OF DRILL HALL, SHOWING SIX RADIATORS ON ONE TYPICAL TRUSS UNIT, ALSO PART OF MAIN AIR SUPPLY DUCT.

WALL SURFACES.

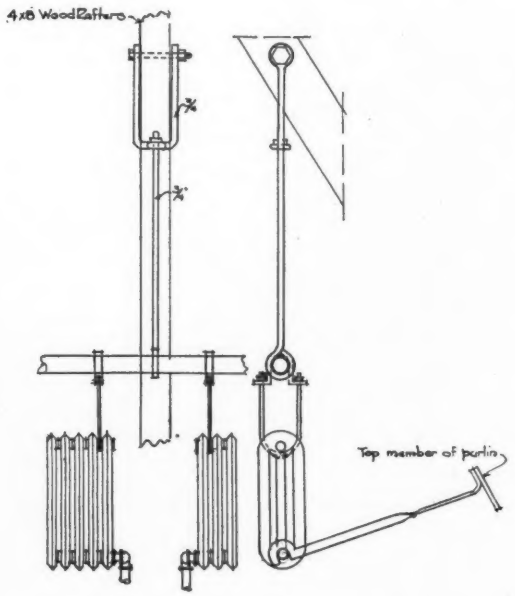
North side, below balcony	6,900	
North side, above balcony	8,200	
South side, below balcony	6,900	
South side, above balcony	8,200	
	30,200	
East end, below balcony.	1,500	
East end, above balcony.	6,500	
West end, below balcony.	1,500	
West end, above balcony.	6,500	
	16,000	
Total wall surface.....		46,200

FLOOR SURFACES.

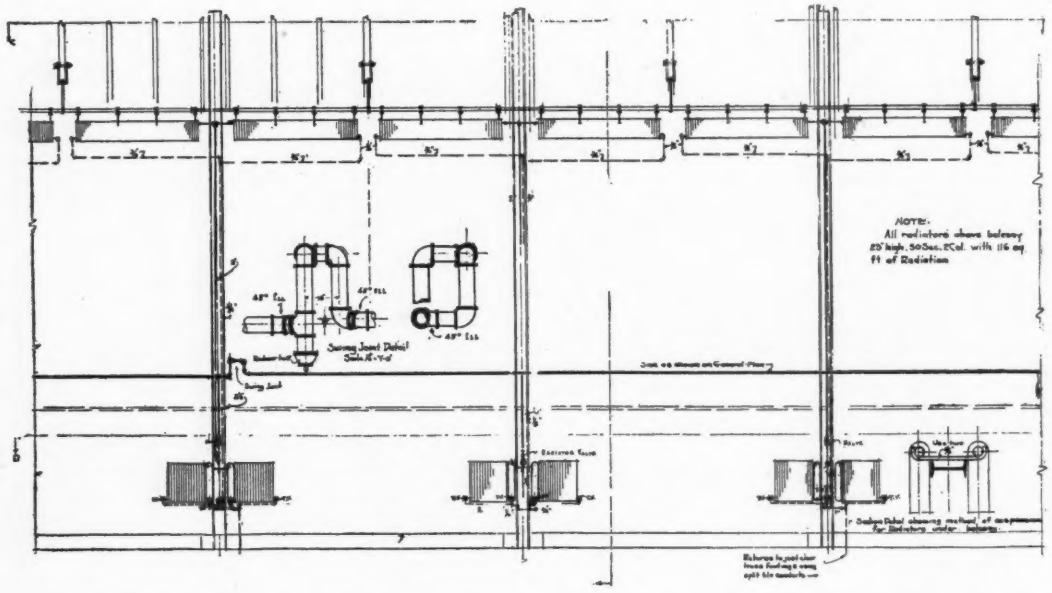
Total for building.....		88,000
North side, below balcony	9,152	
South side, below balcony	9,152	
	18,304	
East end, below balcony.	3,180	
West end, below balcony.	3,180	
	6,360	
Total floor surfaces.....		24,664
In central portion of building..		63,336

ROOF SURFACES.

Total for building (square feet)..		105,000
North side.....	16,240	
South side.....	16,240	
	32,480	
East end.....	1,800	
West end.....	1,800	
	3,600	
Total roof surfaces.....		36,080
In central portion of building..		68,920



DETAIL OF CENTER SUPPORTS FOR RADIATORS ABOVE BALCONY.



DETAIL OF NORTH AND SOUTH SIDES OF ARMORY BUILDING, SHOWING ARRANGEMENT OF COILS AND RADIATORS.

LOSSES AND RADIATION.

Cubic Contents.										Radiator Surface, Sq. Feet.
Below balcony—North	141,400	×	65	÷	55	×	450	=		371
Below balcony—South	141,400	×	65	÷	55	×	450	=		371
Below balcony—East	50,880	×	65	÷	55	×	450	=		134
Below balcony—West	50,880	×	65	÷	55	×	450	=		134
Below balcony—Central Zone	778,200	×	65	÷	55	×	450	=		2,044
Above balcony—North	348,200	×	65	÷	55	×	450	=		914
Above balcony—South	348,200	×	65	÷	55	×	450	=		914
Above balcony—East	106,320	×	65	÷	55	×	450	=		279
Above balcony—West	106,320	×	65	÷	55	×	450	=		279
Above balcony—Central Zone	5,029,525	×	30	÷	55	×	450	=		6,096
Total radiator surface										11,532

65° F. = Temperature Range.

GLASS SURFACES.

Below balcony—North	1,972	×	1	×	70	(a)	÷	450	=		302
Below balcony—South	1,972	×	1	×	70		÷	450	=		302
Below balcony—East	1,630	×	1	×	70		÷	450	=		254
Below balcony—West	1,630	×	1	×	70		÷	450	=		254
Above balcony—East	7,000	×	2	×	70		÷	450	=		2,180
Above balcony—West	7,000	×	2	×	70		÷	450	=		2,180
Total											5,472

Note—The losses through glass surfaces above the balcony were taken at double that for glass surfaces lower down because the wind has a relatively better chance to strike the upper surfaces.

WALL SURFACES.

Below balcony—North	6,900	×	0.4	×	70	(a)	÷	450	=		430
Below balcony—South	6,900	×	0.4	×	70		÷	450	=		430
Below balcony—East	1,500	×	0.4	×	70		÷	450	=		93
Below balcony—West	1,500	×	0.4	×	70		÷	450	=		93
Above balcony—North	8,200	×	0.4	×	65		÷	390	=		546
Above balcony—South	8,200	×	0.4	×	65		÷	390	=		546
Above balcony—East	6,500	×	0.4	×	65		÷	390	=		433
Above balcony—West	6,500	×	0.4	×	65		÷	390	=		433
Total radiator surface											2,998

a = temperature range.

FLOOR SURFACES.

Below balcony—North	9,150	×	0.2	×	30	(a)	÷	450	=		122
Below balcony—South	3,180	×	0.2	×	30		÷	450	=		43
Below balcony—East	3,180	×	0.2	×	30		÷	450	=		43
Below balcony—West	6,336	×	0.1	×	30		÷	450	=		433
Below balcony—Central Zone	9,150	×	0.2	×	30		÷	450	=		122
Total											763

Note—The losses for surfaces below the balconies were taken to be double those for the other floor surfaces because these surfaces are near the wall and, therefore, have a better chance of being cooled by air currents from the outside.

ROOF SURFACES.

North side	16,240	×	0.2	×	60 (a)	÷	450	=	433
South side	16,240	×	0.2	×	60	÷	450	=	433
East side	1,800	×	0.2	×	60	÷	450	=	48
West side	1,800	×	0.2	×	60	÷	450	=	48
Central Zone	68,920	×	0.2	×	40	÷	450	=	1,225
Total									2,187

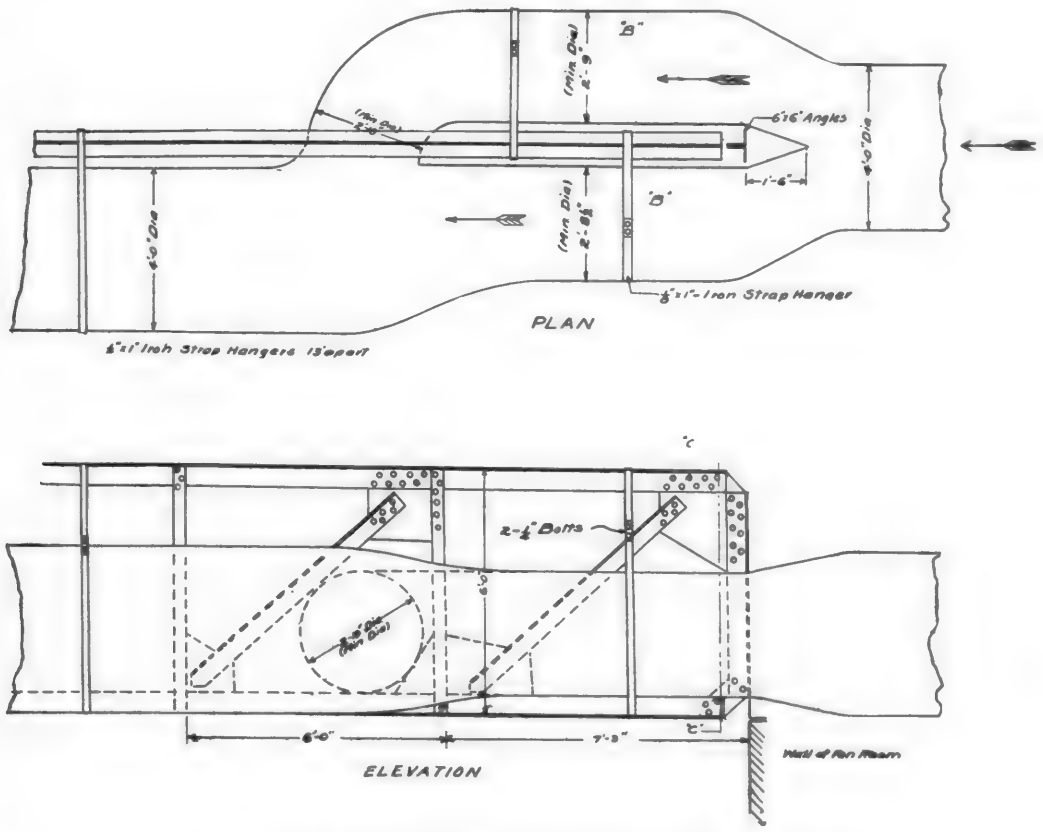
TOTAL RADIATION COMPUTED.

	Sq. Feet.
Cubic Contents	11,532
Glass	5,472
Wall	2,998
Floor	763
Roof	2,187
Radiation Computed	22,952
Radiation Installed	23,632

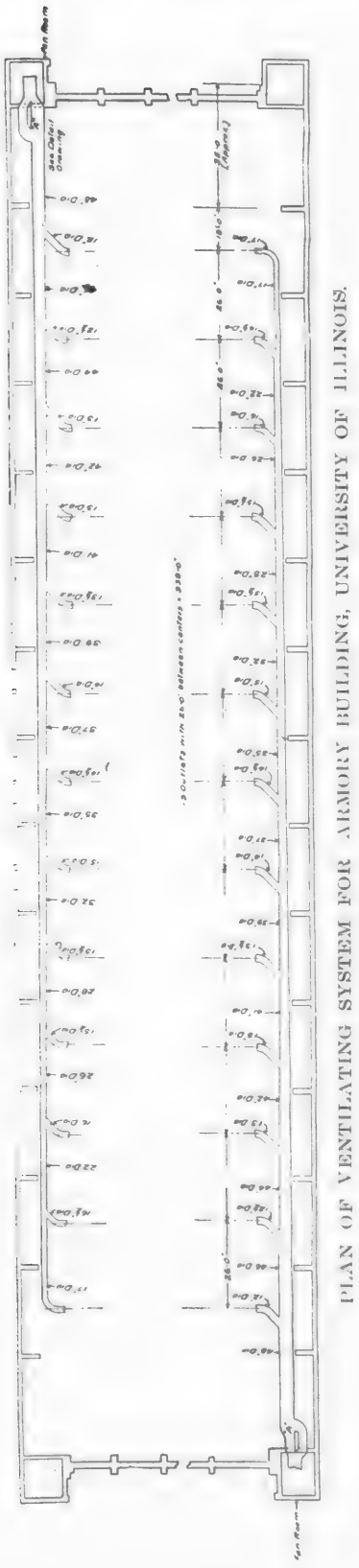
Air Recirculating System.

In order to recirculate the air in the building, or to furnish fresh air should this be required, as well as to produce more active circulation or movement of air at the longitudinal center of the building, two fan units with coils, and duct work are installed, one at the northeast and the other at the southwest corner of the building. Each unit is designed to handle 33,000 cu. ft. of air per minute against a total pressure of 1.35 in. of water, velocity of fan at outlet, 2750 ft. per minute.

The duct into which each fan delivers is 48 in. diameter at the fan and decreases to 18 in. at the last outlet.



DETAILS OF AIR DUCT AT "A," ARMORY BUILDING.
(See plan of Ventilating System.)



PLAN OF VENTILATING SYSTEM FOR ARMORY BUILDING, UNIVERSITY OF ILLINOIS.

Each duct is 380 ft. long and has thirteen outlets, 12 in. to 18 in. diameter, all outlets being fitted with adjustable dampers. The basic data for the design of these ducts are: coefficient of friction 0.0045 (0.0037 + 25%); velocity at last outlet 1600 f.p.m.; volume of air for each outlet 2500 c.f.m. The duct was designed for equal friction pressure loss per foot of length, following the method of Professor L. A. Harding, to whom credit is due for this design.

The high velocity at duct outlets is used in order that the effects might be felt at the center of the building, which is 90 ft. from the duct outlets.

In order to overcome any possible "chimney effect" all outlets are inclined to a line 5 ft. from the floor at the center of the building.

The "roar" at duct outlets is minimized by omitting grills for these outlets.

In the installation of fans, heaters, and ducts, structural conditions necessitated locating the heaters on top of the fans, also splitting the fan outlet to the main duct to obtain the required outlet area.

The heaters are made up of two sections for each fan, 7 ft. wide, 8 ft. high and containing 1168 lin. ft. of 1 in. pipe per section; total for both fans, 4672 lin. ft. Approximate cast iron equivalent, 9500 sq. ft.

The entire system is under Powers temperature control, there being 12 thermostats for direct radiation and two duct thermostats for the fan system.

The accompanying sketches illustrate such features of this problem as seem to be sufficiently out of the ordinary to be of interest.

The heating contractors are Carson-Payson Company, Chicago; fans and duct work, New York Blower Company, Chicago; pipe covering, Smith-Totman Company, Chicago; thermostatic traps, Illinois Engineering Company, Chicago; temperature control, Powers Regulator Company, Chicago.

The principal parts of all work are exposed, and the workmanship and operation of all parts of the system are satisfactory. The system has been in operation one season.

The system is to be subjected to complete tests, to obtain temperatures and amount of condensation, as soon as there is an opportunity.

The Measure of Comfort in Factories

CONSTRUCTION AND USE OF THE KATATHERMOMETER.

BY JAMES A. SEAGER.

It is becoming increasingly realized today that satisfactory manufacturing operations depend very largely upon the reasonable comfort of the worker; that a man or woman cannot carry out the operations involved in a factory process unless physical conditions are such as to make attention to the work possible without distraction. Particularly is this the case where the work involved demands skill either of body or brain. From such a standpoint, the search for the comfort of the employe is not an amiable impulse, but a necessity dictated by one of the elementary laws of success.

For this reason the Katathermometer, made by James Hicks of Hatton Garden, London, is in reality a measure of comfort in factories and offices where it is applied, and is therefore also a measure of efficiency in manufacturing and commercial operations. It owes its origin to Professor Leonard Hill who, working from the principle that comfort and good health depend very largely on the rate of heat loss and evaporation of moisture from the skin and upper air passages, upon the vascular condition of these parts and the excitation of sensory nerves therein by pleasantly cool, moving air, developed the instrument about to be described.

EFFECTS OF CONFINED WARM AIR.

In confined warm air massive infection occurs by the spraying of saliva. The inhalation of trade dust, particularly gritty stone and metal, and the indulgence in alcohol, lessens immunity to disease. By breathing warm air or convected heat the nasal mucous membrane is swollen and the air way is obstructed while convected heat helps to bring about infection. On the other hand, cool air and radiant heat bring the skin into play and keep the nose in a healthy state.

The importance of the above remarks may be practically demonstrated by quoting some figures obtained from the supplementary volume to the 65th Annual Report of the Registrar General (Great Britain) published in 1908. In this some comparative figures for mortality from phthisis among workers are given, the difference between those for open air employments and town and factory occupations being very marked. Taking first of all the open-air workers the comparative figure for railway engine drivers and stokers is 63; that for gamekeepers, 73; agriculturalists, 79; farm laborers 82; gardeners and nurserymen 83, and fishermen 96. Contrasting these with town and factory workers we have that while the figure for the chemical manufacturers is 96, that for printers is 290; for furriers and skinners, 314; brush makers, 314; makers of tools, scissors and the like, 353, messengers and porters (otherwise than railway), 368; costermongers and hawkers, 516; inn and hotel servants, 533; while for inn and hotel servants in London the figure is 667. Thus the mortality of the hotel servants from consumption is about ten times that of the engine drivers and eight times that of agriculturalists. Coal mines and chemical factories have a low phthisis mortality, probably owing to the necessity for good ventilation therein. The argument may be strengthened by reference to another authority. According to Hindhede, in Denmark out of every 10,000 people 2,700 die in Copenhagen between the years of 40 and 60, who, if living in the country, would die between the years 60 and 90.

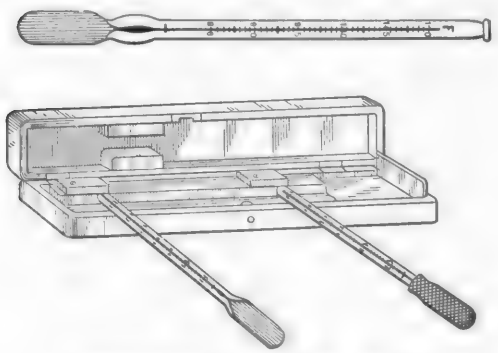
RATE OF HEAT AND INFLUENCE OF MOVING AIR IMPORTANT FEATURES.

It should be remembered in connection with the above that the ordinary wet and dry bulb thermometers give no indication of the rate of heat loss and of the important influence of moving air, these being, as shown above, factors of primary importance in securing comfort. This is demonstrated by the fact that in a closed chamber heated to say 85° F., dry bulb, and 80° F. wet bulb, so long as the air is well stirred by a fan the atmosphere feels cool and comfortable. On stopping the fan, however, while the

change in temperature indicated by the thermometer is almost imperceptible the atmosphere at once becomes unpleasantly warm and uncomfortable. The katathermometer is therefore designed to take account of these factors, or, in other words, to indicate the sensation actually experienced by the human body.

CONSTRUCTION OF KATATHERMOMETER.

In construction this instrument consists of two large-bulbed spirit thermometers the stems of which are marked at 110° F., 100° F. and 90° F. Another



PROFESSOR LEONARD HILL'S KATATHERMOMETER.

mark is made just above the bulb in each case. In one thermometer the bulb is covered with a finger-stall taken from a muslin glove, this being the wet-bulb instrument. The finger-stall holds the least amount of water sufficient for taking an observation. The bulb of the other thermometer is uncovered.

In use, both bulbs are immersed in water at about 110° F. up to the mark just above the bulb. When the menisci have reached about 110° F., the instruments are withdrawn. The bare bulb is rapidly dried on a soft cloth, while the excess of water is jerked off the bulb and covering of the other thermometer. It should be noted, by the way, that if the column of spirit is not continuous the instrument is jerked till this condition is obtained, or the bulb is heated until the spirit rises into the top reservoir. After immersing and drying as indicated the instruments are rested in clips provided and the time required for the meniscus of each instrument to drop from 100° to 90° F. is taken with a watch. If a stop watch is used, when the falling meniscus reaches 100° F. the watch is started, and stopped when the meniscus reaches 90° F.

In this way the rate of cooling of the wet and dry instruments at about body temperature is found. Further readings may be taken with the instruments exposed to or screened from a source of radiant heat, or exposed to or screened from wind or draft, or again with a thick knitted finger-stall placed over the bulb to imitate the effect of clothes. In this way the various conditions affecting the comfort of the human body may be studied. When the finger stall just mentioned is damped, its efficiency is greatly diminished, illustrating the cooling effect of damped clothes. The effect of the color and texture of clothes may also be demonstrated.

A white finger-stall allows the instrument to cool when exposed to sunlight much more quickly than a dark finger-stall, as the latter absorbs the light rays and converts them into heat rays. This is what would be expected by anyone knowing the value of white clothes in tropical or semi-tropical areas.

HOW A STANDARD OF VALUE WAS REACHED IN CONNECTION WITH THE READINGS.

It may be interesting to give some account of the way in which some standard of value was reached in connection with the readings obtained by this instrument. The graduation of the Katathermometer has, of course, to be empirical, and the process was effected by taking readings out of doors on an ideal spring day in sunshine, with a gentle, cool breeze. The shade temperature was 62° F. It was then found that the wet bulb fell from 100° F. to 90° F. in 45 seconds, while the time taken for the dry bulb was 2 minutes 25 seconds. Screened from the sun, the dry bulb fell in 1 minute 46 seconds. With a thick knitted glove, the wet bulb fell in 1 minute 50 seconds, the dry bulb falling in 6 minutes 27 seconds. Screened from the sun, the dry bulb fell in 4 minutes 23 seconds. The radiant heat of the sun produced a marked effect on the dry bulb enclosed in the thick dark glove, and the observer in the same degree felt the warmth of the sun on his back. It may be noted that the variation of the temperature in different parts of

the skin contributes to comfort and well-being. This constitutes an advantage of radiant heat, and a disadvantage of systems in which air is heated by convection.

In a room, on the same spring day, with the window wide open, under pleasant conditions, the air moving, and no fire, the wet bulb fell in 58 seconds, while the dry bulb fell in 2 minutes 43 seconds. On another ideal spring day with a shade temperature of 63° F. the wet bulb fell in 40 to 51 seconds, while the dry bulb fell in 2 minutes 10 seconds to 2 minutes 40 seconds. The times varied with the strength of the breeze and the instruments showed how the stimulation of the skin varies with the breeze out-of-doors. Shielded from the sun the wet bulb fell in 35 seconds, the dry bulb falling in 1 minute 28 seconds.

On another spring day, which was not ideal, in a cold, raw wind with spots of rain falling, the wet bulb fell in 24½ seconds, the dry bulb falling in 55½ seconds. Inside the room, with open fire and comfortably warm, the wet bulb fell in 1 minute 9 seconds, the dry bulb falling in 3 minutes 5 seconds. On another day with a cold wind blowing, with a temperature of 54° F. and when an overcoat was felt to be necessary the wet bulb fell in 25 seconds and the dry bulb fell in 51 seconds. With the thick glove on the instrument the time of fall for the wet bulb was 55 seconds and for the dry bulb, 2 minutes 5 seconds. In a room with no fire and with windows shut the times were 53 seconds and 2 minutes 13 seconds for the wet and dry bulbs, respectively. Hence the effect of the shelter afforded by the walls of the room was about the same as that given by the thick glove outside. In a room with a fire and no windows open, at a temperature of 60½° F., the atmosphere being comfortable but slightly too windless, the wet bulb fell in 1 minute 7 seconds while the dry bulb took 3 minutes 8 seconds.

OTHER RESULTS OF TESTS.

On another day with a strong fresh wind blowing and a temperature of 60½° F. the wet bulb fell in 31½ seconds and the dry one in 1 minute 21 seconds. In a more exposed place the time for the wet bulb was 26 seconds, and for the dry bulb 49½ seconds. With the thick glove on, the times for the wet and dry bulb were 1 minute 4 seconds and 3 minutes 3 seconds. These figures show how relatively great is the cooling effect of wind, and the protection afforded by clothes. Other interesting tests were as follows: On a mild day with slight rain and little breeze, with a temperature of 52° F. the time was 34 seconds for the wet and 1 minute 22 seconds for the dry bulb. On a warm May day in a room with windows wide open the wet bulb fell in 1 minute 1 second, the dry bulb falling in 3 minutes 7 seconds. Out of doors in the warm sunlight the times were 44 seconds and 4 minutes 47 seconds for the wet and dry bulbs. In a railway restaurant car where the atmosphere felt unpleasantly warm and windless, the wet bulb fell in 1 minute 5 seconds while the dry bulb took 4 minutes 10 seconds. In a room heated by anthracite stove to 70° F. (dry) and 62° F. (wet), and unpleasantly warm, the wet bulb fell in about 1 minute 30 seconds and the dry bulb took 4 minutes 30 seconds to five minutes.

The last result is especially interesting. In a room heated by an anthracite stove, which chiefly provides convected heat, the effect on the Katathermometers of screening them from the stove is very slight. In the same room heated by a modern gas fire fitted with a flue, giving radiant heat, screening makes a very great difference, and the instruments show that by such a fire the parts of the room and its occupants are unequally heated and conditions of uniformity avoided. In a chamber heated to 84° F. dry bulb and 77° F. wet bulb, the dry bulb Katathermometer fell in 7 minutes and the wet bulb in 2 minutes 15 seconds. On putting on a fan the dry bulb fell in 3 minutes 39 seconds and the wet bulb in 1 minute 33 seconds, while the ordinary thermometer scarcely varied.

WHAT THE RESULTS SHOWED.

From the above tests and results given by Mr. Hicks the conditions attendant on the healthy conditions of rooms, factories and the like can be gauged. These are that a room is best heated by an open fire or modern gas fire, that is to say, by sources of radiant rather than

convected heat, and ventilated with fresh outside air, gently moving, and so kept as near as possible to the conditions of an ideal spring day. The nearer the approximation to these conditions that can be obtained, the better are the conditions as regards health, comfort and working efficiency. The air used for ventilation should not be heated, as heat gives the same discomfort as desert air or a close day. The heating and ventilation of rooms should be arranged so that the Katathermometer wet bulb falls from 100° F. to 90° F. in about one minute and the dry bulb in about three minutes. These times may with advantage be less —for example, 50 seconds and 2 minutes 30 seconds, respectively—but they should not be much exceeded. In view of the importance of physical comfort in shops, factories, offices and buildings of all description, the development of a means of definitely grading the conditions of such comfort in terms of physical quantities is a remarkable development warranting the reference here given.

Dust and Bacteria Content of City Air

WITH SPECIAL REFERENCE TO SUB-BASEMENTS, FRESH AIR SCHOOLROOMS, STREET CARS AND OPEN SPACES.

BY MELVILLE C. WHIPPLE,
Instructor in Sanitary Chemistry, Harvard University.

(From a paper read before the American Public Health Association and published in the Association's "American Journal of Public Health.")

In view of the fact that there is only a small amount of published information which gives reasonably accurate figures for the numbers of dust particles and bacteria in the air, this paper is presented as a compilation of the results obtained over a fairly wide range of conditions.

METHOD OF PROCURING SAMPLES.

For securing samples of air for dust and bacterial analysis the device manufactured by Wallace and Tiernan, 136 Liberty Street, New York City, has been used. It consists of a wooden box 9 in. x 12 in. x 8 in., within which is either a direct or alternating current motor that operates on any 110-volt circuit. A small pump is operated by the motor and this draws in air from the outside of the box through a glass adapter tube that fits into a metal receiving cup. A tight joint is made by means of a rubber gasket. The adapter tube contains a ½-in. layer of sand for the retention of bacteria and this is later washed out from the tube with sterile water. For the collection of dust particles a ½-in. lever of resorcinol crystals is employed. The crystals are later dissolved in perfectly clean water and counted under the microscope with the use of a 16 mm. objective. Particles from one micron upward can be enumerated in this way. The employment of this method calls for extreme care and scrupulous cleanliness in the preparation of apparatus and the subsequent procedure. Consistent results cannot be obtained unless such precautions are taken.

Examination of dust by the method already outlined, using the microscope, does not reveal the presence of particles smaller than about 1 micron, 0.001 mm. This is unfortunate, as it may be that different atmospheres vary greatly in their content of particles smaller than this, particles that might almost be said to be "colloidal" in size. Likewise those atmospheres that are most sought for by mankind, in the belief that there are benefits derived from life in them, are cleaner than those that envelope populated communities. Determinations of dust made by the writers in the summer season showed 18,000 particles per cubic foot in the air over Long Island Sound, 27,000 at the fifty-seventh story of the Woolworth Building in New York at a time when the street air showed 221,000, and 25,000 particles after a heavy summer shower in Cambridge, Mass., where the normal dry weather content was 200,000 or over. Attention is called to the close agreement between these three determinations, representing as they do the dust in air under conditions of obvious cleanliness.

TABLE I.—SUMMARY OF ANALYSES OF AIR MADE AT LAWRENCE HALL SCHOOL.

Date 1914.	Dust particles per cu. ft.			Bacteria per cu. ft.					
				Gelatine at 20° C.			Agar at 38° C.		
	Outside air.	Kindergarten.	First grade.	Outside air.	Kindergarten.	First grade.	Outside air.	Kindergarten.	First grade.
Jan. 8.....	.....	.....	140,000	..	..	16	..	..	7
Jan. 16.....	68,000	185,000	228,000	3	43	27	0	7	13
Jan. 28.....	98,700	107,000	147,000	0	27	50	0	8	15
Feb. 26.....	264,000	311,000	363,000	10	10	20	0	13	33

Carbon dioxide determinations made on Jan. 28 gave the following results:

Outside air = 3.5 parts per 10,000.
Kindergarten = 4.25 parts per 10,000.
First grade = 5.0 parts per 10,000.

Temperature and Humidity Readings.

Date 1913-14.	Outside air.			Kindergarten			First Grade		
	Temperature F°.	Relative humidity per cent.	Abs. humid. grains cu. ft.	Temperature F°.	Relative humidity, per cent.	Abs. humid. grains cu. ft.	Temperature F°.	Relative humidity, per cent.	Abs. humid. grains cu. ft.
Dec. 12.....	33.0	60	1.316	57.5	39	2.059	56.0	40	2.006
Dec. 18.....	42.5	75	2.340	63.0	45	2.857	58.0	52	2.792
Jan. 8.....	36.0	60	1.474	50.0	39	1.590	49.0	40	1.574
Jan. 16.....	26.0	73	1.185	60.5	30	1.753	56.0	35	1.756
Jan. 28.....	45.5	79	2.746	59.5	50	2.825	57.5	53	2.798
Feb. 13.....	12.0	47	.402	60.0	15	.861	...	..	....
Feb. 26.....	35.5	28	.662	62.0	16	.982	58.5	21	1.148

CONDITIONS IN A SMALL FRESH AIR SCHOOL.

In Table I are given the results of several determinations of dust and bacteria made in a small fresh air school in Cambridge, Mass. There were two rooms, one for kindergarten instruction, the other for first grade work. The dimensions of the first were 21 ft. x 40 ft. and of the latter 10 ft. x 31 ft. Ceilings were 13 ft. high. There was no mechanical system of ventilation and air was taken into the room through several large windows and transoms, principally the latter, along one side of each room. A temperature between 50° and 60° F. was maintained throughout the winter. In each room there were about twenty small children and the teacher, the unit volume of air space accordingly being about 500 cu. ft. per person in the kindergarten and 200 cu. ft. in the first grade.

In all cases the dust particles and the bacteria were more numerous in the air of the rooms than in that of the outside air, varying, no doubt, with the amount of disturbance in each room. Likewise, with one exception, the first grade room showed higher counts than the kindergarten room. The smaller volume of air per occupant in this room accounts for this fact. The actual number of children was about the same.

These results are given merely as an illustration of the greater number of bacteria and dust particles that are present in the indoor air of one class of occupied rooms. The numbers are not excessive for schoolrooms, and are, in fact, considerably lower than the average results obtained by Winslow in the New York City schools. This might be expected, as one of the advantages of a fresh air school, the object of which is to provide a rapid change of air between the inside and outside atmospheres.

An interesting sidelight upon this particular fresh air school is the fact that the teachers went through the entire winter without colds, although they had been subject to them in previous years while teaching in the ordinary schoolrooms where mechanical systems of ventilation and higher temperatures were in use. The cool temperature of the rooms, as shown in the table, may have been quite as much of a factor as was the ventilation in maintaining the good health tone.

QUALITY OF THE AIR IN SUB-BASEMENTS.

How best to improve atmospheric conditions in the basements and sub-surface floors of buildings has long been a prob-

lem with department store proprietors. It has been hard to approach the improved standards applied to the upper floors, owing to the fact that mechanical means must be employed to change the air, and these must be on a scale larger than ordinarily used because of the great volumes of air to be handled, the absence of air movement below the street surface, the heat radiated from artificial lighting, and the larger crowds that frequent the basement departments. Table II gives the results of some studies in a large Boston store, where considerable attention has been given to the ventilation of the basement floor and the mezzanine floor just above it. The latter is described in the table as the "basement balcony." Washed air taken from the roof is supplied to these floors. It does not furnish the entire supply, however, as the exhaust system handles a volume several times larger, the difference being made up by leakage inward from stairways, wells and other openings.

The number of dust particles at various places in the basement was considerably higher than in the incoming washed air or the outside air. Microscopical examination showed that many of the particles were of fibrous structure. The handling of clothes and dry goods and the contact of large numbers of people in passing about the store would naturally give rise to a considerable amount of dust of this character.

There was a striking difference in the number of bacteria in the washed air and that in the store. A considerable increase was shown both in the forms growing at 20° C. and those growing at 37°.

It will be seen that the figures given for the store in Table II exceed those given for the fresh air school in Table I. This serves as an illustration of the way in which indoor air becomes unclean by use, the degree depending upon the extent of usage and the frequency of change. The basement referred to above had an elaborate installation for renewing its atmosphere and was fairly comfortable as to temperature and humidity. The ventilation system did not accomplish as perfect results, however, from the standpoint of air cleanliness. The figures given for dust and bacteria are slightly in excess of the average results given by Winslow for New York City schools.

DUSTY CONDITIONS IN STREET CARS.

During the routine of life in large cities there is probably no other place where the population mingles in closer personal contact, or under more abnormal conditions of ventilation, than in the cars of our transportation systems.

The air in street cars is subject to unusual contamination from two sources: first, from the large number of persons occupying a given cubical space, and, second, from the streets over which the cars pass.

With the idea of obtaining information relative to the dust and bacteria content of air in street cars, some studies were made on the line of the Boston Elevated Railway Co., running between Harvard Square in Cambridge and Pleasant Street in Boston. The results are given so far as obtained, and are of interest as showing the conditions at the particular time

TABLE II.—SUMMARY OF ANALYSIS OF AIR TAKEN FROM THE BASEMENT AND BASEMENT BALCONY IN A DEPARTMENT STORE, BOSTON. APRIL 3, 1914.

Hour.	Location.	Bacteria per cu.ft. Gelatine at 20°.	Bacteria per cu.ft. Agar at 38°.	Dust particles per cu. ft.	Temperature. Dry bulb, Deg. F.	Temperature. Wet bulb, Deg. F.	Relative humidity, per cent.	Remarks.
11.00 a.m.	Intake of air washer....	33	3	137,000	...	...	..	.....
11.10 a.m.	Intake of air washer....	..	..	.....	54.5	46.0	50	Air taken in at roof
11.30 a.m.	Washed air from washer	17	3	68,000	58.5	51.5	61	Sample in duct
1.05 p.m.	Basement, N. E. corner..	150	10	262,000	60.5	47.5	34	Near freight elev't'rs
1.45 p.m.	Basement, N. W. corner.	200	53	423,000	70.0	54.0	33	Near Exit CC
1.55 p.m.	Basement, S. W. corner..	...	..	.....	70.0	53.5	31	Near Exit DD
2.10 p.m.	Basement, S. S. center..	223	67	476,000	...	...	..	.....
2.15 p.m.	Basement, S. S. center..	...	..	.....	72.0	54.5	29	Ladies' suit dept.
3.00 p.m.	Balcony near stair well.	160	23	321,000	...	...	..	.....
3.05 p.m.	Balcony near stair well.	..	..	.....	73.0	57.0	35	North Side
3.15 p.m.	Balcony near restaurant.	..	..	.....	74.5	58.0	34	South Side
3.30 p.m.	Balcony, S. W. corner...	90	10	388,000	...	...	..	.....
3.30 p.m.	Balcony, S. W. corner...	..	..	.....	69.5	52.0	27	Near Exit DD

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QUALITY OF THE AIR IN SUB-BASEMENTS.

How best to improve atmospheric conditions in the basements and sub-surface floors of buildings has long been a prob-

lem with department store proprietors. It has been hard to approach the improved standards applied to the upper floors, owing to the fact that mechanical means must be employed to change the air, and these must be on a scale larger than ordinarily used because of the great volumes of air to be handled, the absence of air movement below the street surface, the heat radiated from artificial lighting, and the larger crowds that frequent the basement departments. Table II gives the results of some studies in a large Boston store, where considerable attention has been given to the ventilation of the basement floor and the mezzanine floor just above it. The latter is described in the table as the "basement balcony." Washed air taken from the roof is supplied to these floors. It does not furnish the entire supply, however, as the exhaust system handles a volume several times larger, the difference being made up by leakage inward from stairways, wells and other openings.

The number of dust particles at various places in the basement was considerably higher than in the incoming washed air or the outside air. Microscopical examination showed that many of the particles were of fibrous structure. The handling of clothes and dry goods and the contact of large numbers of people in passing about the store would naturally give rise to a considerable amount of dust of this character.

There was a striking difference in the number of bacteria in the washed air and that in the store. A considerable increase was shown both in the forms growing at 20° C. and those growing at 37°.

It will be seen that the figures given for the store in Table II exceed those given for the fresh air school in Table I. This serves as an illustration of the way in which indoor air becomes unclean by use, the degree depending upon the extent of usage and the frequency of change. The basement referred to above had an elaborate installation for renewing its atmosphere and was fairly comfortable as to temperature and humidity. The ventilation system did not accomplish as perfect results, however, from the standpoint of air cleanliness. The figures given for dust and bacteria are slightly in excess of the average results given by Winslow for New York City schools.

DUSTY CONDITIONS IN STREET CARS.

During the routine of life in large cities there is probably no other place where the population mingles in closer personal contact, or under more abnormal conditions of ventilation, than in the cars of our transportation systems.

The air in street cars is subject to unusual contamination from two sources: first, from the large number of persons occupying a given cubical space, and, second, from the streets over which the cars pass.

With the idea of obtaining information relative to the dust and bacteria content of air in street cars, some studies were made on the line of the Boston Elevated Railway Co., running between Harvard Square in Cambridge and Pleasant Street in Boston. The results are given so far as obtained, and are of interest as showing the conditions at the particular time

TABLE II.—SUMMARY OF ANALYSIS OF AIR TAKEN FROM THE BASEMENT AND BASEMENT BALCONY IN A DEPARTMENT STORE, BOSTON. APRIL 3, 1914.

Hour.	Location.	Bacteria per cu.ft. Gelatine at 20°.	Bacteria per cu.ft. Agar at 38°.	Dust particles per cu. ft.	Temperature. Dry bulb, Deg. F.	Temperature. Wet bulb, Deg. F.	Relative humidity, per cent.	Remarks.
11.00 a.m.	Intake of air washer....	33	3	137,000	...	...	..	.....
11.10 a.m.	Intake of air washer....	..	..	.....	54.5	46.0	50	Air taken in at roof
11.30 a.m.	Washed air from washer	17	3	68,000	58.5	51.5	61	Sample in duct
1.05 p.m.	Basement, N. E. corner..	150	10	262,000	60.5	47.5	34	Near freight elev't'rs
1.45 p.m.	Basement, N. W. corner.	200	53	423,000	70.0	54.0	33	Near Exit CC
1.55 p.m.	Basement, S. W. corner..	...	..	.....	70.0	53.5	31	Near Exit DD
2.10 p.m.	Basement, S. S. center..	223	67	476,000	...	...	..	.....
2.15 p.m.	Basement, S. S. center..	...	..	.....	72.0	54.5	29	Ladies' suit dept.
3.00 p.m.	Balcony near stair well.	160	23	321,000	...	...	..	.....
3.05 p.m.	Balcony near stair well.	..	..	.....	73.0	57.0	35	North Side
3.15 p.m.	Balcony near restaurant.	..	..	.....	74.5	58.0	34	South Side
3.30 p.m.	Balcony, S. W. corner...	90	10	388,000	...	...	..	.....
3.30 p.m.	Balcony, S. W. corner...	..	..	.....	69.5	52.0	27	Near Exit DD

and place at which determinations were made.

The line in question extends over four miles of the Boston Elevated Railway system, approximately half of the distance being surface line, the balance being divided between one of the Boston subways and a long viaduct passing over the Charles River and a portion of Boston. The cars in use were the large semi-convertible type, known as 4A2 and having closed vestibules and cross seats with a center aisle. Air was admitted to the cars by means of two deck-sash ventilators at either end, and by means of twelve curtain ventilators along the roof of the car, six of which were always open, the remaining ones closed. Samples of the air were collected at the center of the car. The results of analyses for dust particles and bacteria are given in Table III and are shown graphically in diagrams 1 and 2. From eight to ten minutes were required for the taking of each sample, during which time the car was moving. The portion of the route over which the car moved during the taking of each sample is indicated in the diagram and in the tables the maximum and minimum numbers of passengers are given for each portion of the route.

Diagrams 1 and 2 show the route over which samples were taken, the character of the route at different points, and the approximate distances between stations. The figures for bacteria and dust appear above and below the representation of the route, and the line under each of them indicates the distance over which the sample was taken.

Comparison of the two diagrams shows a decided difference in the number of bacteria and dust particles on a damp and on a dry day, the latter showing the higher results. The figures presented are much higher than those given for samples collected in other places mentioned in this paper. In one case the dust particles numbered 3,415,000 per cubic foot. This was in a section of Cambridge where a large force of men was engaged in removing the winter's accumulation of street dirt.

SUBWAY AIR LESS CLEAN THAN OUTDOOR AIR.

Judging from the rather limited number of determinations made, there is a tendency for the subway air to be less clean than the outside air over the streets. In general, higher results were obtained on portions of the route lying in the subway. The dust particles collected in the

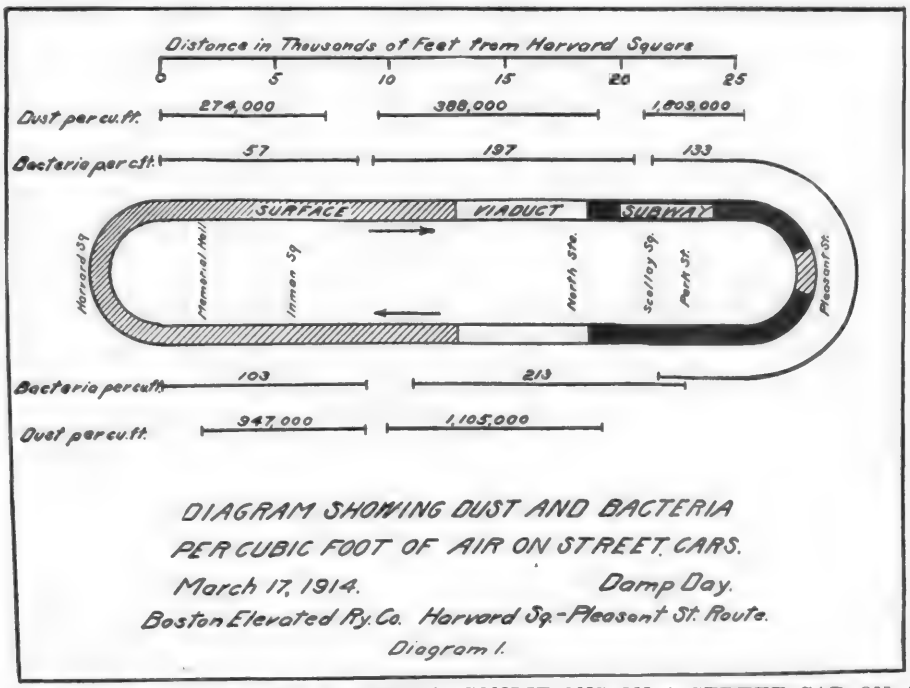

DIAGRAM 1—DUST AND BACTERIA CONDITIONS ON A STREET CAR ON A DAMP DAY.

subway had a smaller average diameter and under the microscope were darker in color. The work of Soper in the New York subways has shown that a very considerable amount of metallic dust is present in subway air. This results from the wearing down of rails, wheels and brake shoes. Samples taken on the viaduct or in passing over it might be expected to give lower results on account of the greater purity of the atmosphere; but in passing from a rather dirty section of Cambridge in one direction, and from the subway in the other direction, with doors and windows closed, there was a considerable lag in the change of atmosphere within the cars.

In connection with Table III it will be noticed that the dust and bacteria content of the outside air at Pierce Hall, as registered on the days when samples were taken in the cars, was very much lower. This might be expected when consideration is given to the agitation surrounding the movements of street cars and the amount of dust and dirt that is brought into them by passengers.

The variation from day to day in the dust content of city air in a place removed from the influences of car traffic is illustrated by the figures given in Table IV. The results are for an eleven-day period following shortly after April 1, 1914, the date of the street car observations given in Diagram 2. A wide range of weather conditions is covered by the period. Each sample examined was a composite one made up by collecting the dust at three or four different intervals during the day.

In general, the figures in the table show that dust particles were most numerous when the streets were dusty and the wind movement great. Exceptions to this occurred on April 8, a foggy day with no wind, and on April 12 and 13, when there were high winds and fair weather. It is an observed fact that on quiet days with high humidity conditions a large amount of soot and dirt is deposited from city atmosphere. This may explain the result for April 8. The low results of April 12 and 13 were coincident with a shifting of the wind to northerly directions and a lowering of temperature. This followed a very light rain on the night of April 11. The movement of large volumes of air from northerly points nearly always results in a clearing of the atmosphere in Cambridge.

A general inspection of all the results

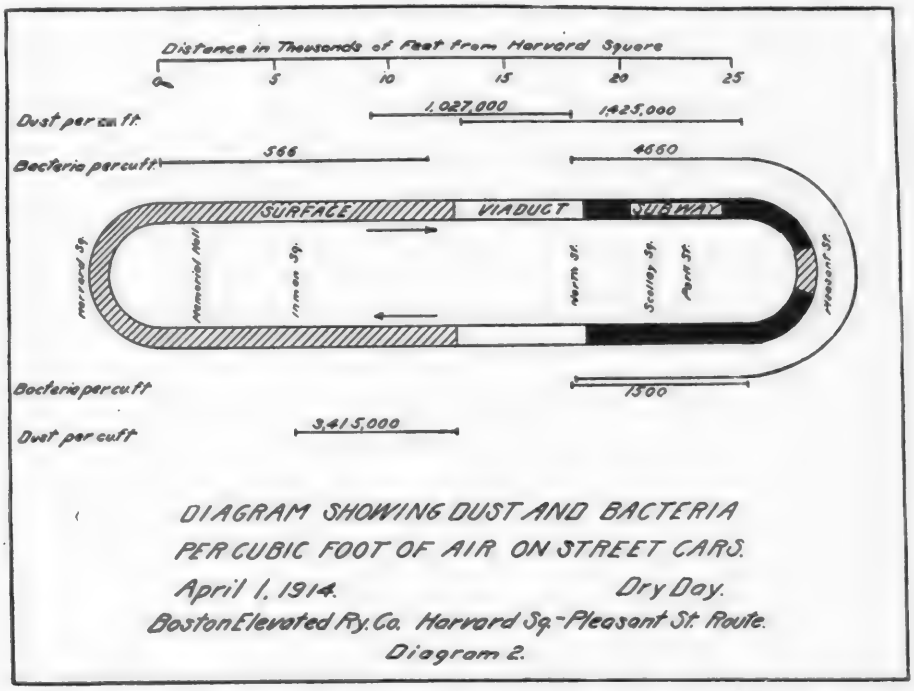

DIAGRAM 2—DUST AND BACTERIA CONDITIONS ON A STREET CAR ON A DRY DAY.

presented in this paper shows that, although the dust and bacteria contents of air in different places, both indoors and out-of-doors, vary from day to day, there are distinct differences that mark the increased cleanliness of one place over another. These differences are measurable by the methods that have been described. Outdoor air may be said in nearly all cases to be cleaner than the same air after use in occupied places. Its initial purity will depend upon two things, the source from which it is taken, and the meteorological conditions prevalent.

The dust and bacteria in the air of occupied places has been shown to vary greatly with the character of the place. The amount is, of course, influenced by a great many factors. The cleanliness of inside air may be judged by the total numbers of dust particles and bacteria present, regardless of whether the increase over the numbers in the incoming outside air is large or small. If the increase is large, measures should be taken on the inside to reduce the numbers, either by supplying a larger quantity of outside air or by eliminating dirty conditions within. If the incoming air is unclean it should be subjected to some cleansing process, or else the source of supply should be changed.

The above investigation was made in the Laboratory of Sanitary Engineering of Harvard University under the general direction of Professor George C. Whipple, and was made possible by funds kindly furnished by Mr. Ernest C. Dane of Brookline.

Through an oversight, a note was omitted in the August issue that the paper by C. C. Wilcox on "A Pressure Survey Study Constituting a Report on the Comparative Use of Exhaust and Live Steam for Heating" was presented at the recent annual convention of the National District Heating Association, in Chicago.

TABLE III.—SUMMARY OF ANALYSES OF AIR. SAMPLES TAKEN IN CARS OF BOSTON ELEVATED RY. CO. HARVARD SQUARE—PLEASANT STREET LINE.

Bacteria.

March 17, 1914.*

Section of route.	Bacteria per cu. ft. Gel. at 20°C.	Bacteria per cu. ft. Agar at 38°C.	Number of passengers.
Harvard Square to East Cambridge	57	43	7 to 35
Scollay Square to Pleasant St. and return	133	57	30
East Cambridge to Harvard Square	103	43	5 to 25
East Cambridge to Scollay Square	197	193	12 to 26
Park Street to East Cambridge	213	187	17 to 50
Outside air, Pierce Hall	33	17	.....
April 1, 1914.†			
Harvard Square to East Cambridge	566	67	9 to 45
Pleasant Street to North Station	1,500	1,080	7 to 33
North Station to Pleasant Street and return.	4,660	3,330	4 to 26
Outside air, Pierce Hall	117	10	.....

Dust Particles.

March 17, 1914.*

Section of route.	Dust particles per cu. ft.	Number of passengers.
East Cambridge to Scollay Square	388,000	35 to 67
Haymarket Equare to East Cambridge	1,105,000	25 to 30
Harvard Square to East Cambridge	274,000	5 to 19
Scollay Square to Pleasant Street	1,809,000	4 to 26
East Cambridge to Memorial Hall	947,000	20 to 40
Outside air, Pierce Hall	133,000	.....
April 1, 1914.†		
Viaduct to Pleasant Street	1,425,000	7 to 54
Viaduct to Inman Square	3,415,000	19 to 30
East Cambridge to North Station	1,027,000	26 to 27
Outside air, Pierce Hall	122,000	.....

*The streets on this day were damp from rain that had fallen a few hours previously.
†The streets on this day were dusty, following two days of dry weather and brisk winds.

TABLE IV.—SHOWING NUMBER OF DUST PARTICLES IN OUTSIDE AIR ON DIFFERENT DAYS. HARVARD UNIVERSITY, CAMBRIDGE, MASS.

Dust particles per cu. ft. at Pierce Hall.*	Date.	8 a. m. Wind.	8 a. m. Weather.	4 p. m. Wind.	4 p. m. Weather.	Remarks.
	Apr. 2			Light E.	Clear to rain	Streets wet. Snow at night
	Apr. 3	Light W.	Cold Clearing	Brisk N. W.	Fair	Freezing during night
280,000.....	Apr. 4	Fresh N. W.	Cold Fair	Fresh W.	Fair	Streets dusty after noon
116,000.....	Apr. 5	Light S. W.	Cold Cloudy	Fresh S. W.	Clearing	Light rain up to noon
177,000.....	Apr. 6	Light W.	Cold Fair	Light S. W.	Fair	Streets somewhat dusty
158,000.....	Apr. 7	Brisk N. E.	Cold Rain	Light N. W.	Cloudy	Streets very muddy
226,000.....	Apr. 8	V. Light N. W.	Cold Foggy	Light S. E.	Mist	Streets muddy all day
91,000.....	Apr. 9	Fresh N. W.	Mild Clearing	Brisk N. W.	Partly cloudy	Streets became partially dried
113,000.....	Apr. 10	Brisk W.	Cold Fair	Fresh S. W.	Fair	Streets dusty
366,000.....	Apr. 11	Brisk S. to High	Mild Fair	High S.	Fair	Very dusty day Light rain in night
139,000.....	Apr. 12	Brisk S. W.	Mild Fair	High N. W.	Fair	Not much dust until noon. Gale late in P. M.
121,000.....	Apr. 13	Brisk N.	Cold Fair	Fresh N. W.	Fair	
109,000.....	Apr. 14	Fresh S. W.	Cold Fair	Light S. W.	Fair	

*Composite samples taken at different hours of the day.

Three Methods of Measuring Radiant Heat From Gas Fires

Much interest was aroused at the last meeting of the heating engineers' society by the description given by George S. Barrows of a method for determining the amount of radiant heat given off by gas radiators. This description, published in THE HEATING AND VENTILATING MAGAZINE for May, 1915, is now supplemented by an account of the way radiant heat from gas fires is measured in England, as given by W. R. Twigg in Domestic Engineering (London).

WATER FLOW RADIOMETERS USED.

The first method is by the use of the water flow radiometer, as it is termed, designed by J. G. Clark, of the technical staff of the Gas Light & Coke Co. This apparatus is shown in Fig. 1 and consists of a copper tube of rectangular section, 2 in. x ⅛ in. inside dimensions. The tube is 54 in. long. One surface is blackened and used to absorb radiation, while the other surfaces are polished to reduce radiation. The tube is suspended on a suitable stand in such a way that heat cannot readily travel from one to the other by conduction. Water is caused to enter the tube at the bottom and to pass away at the top through a funnel switch. Thermometers graduated to 1/10° C. are provided at the top and bottom waterways to indicate the temperature of inlet and outlet water streams. The whole is mounted upon a quadrant base. This quadrant is reversible and can be used on either side of the fire under test, thus forming a complete semi-circle around the center of the fire. Holes are provided in this quadrant 10° apart, corresponding with pegs in the tripod foot of the stand, thus enabling the apparatus to be quickly and accurately placed in various positions around the fire, so that the blackened sur-

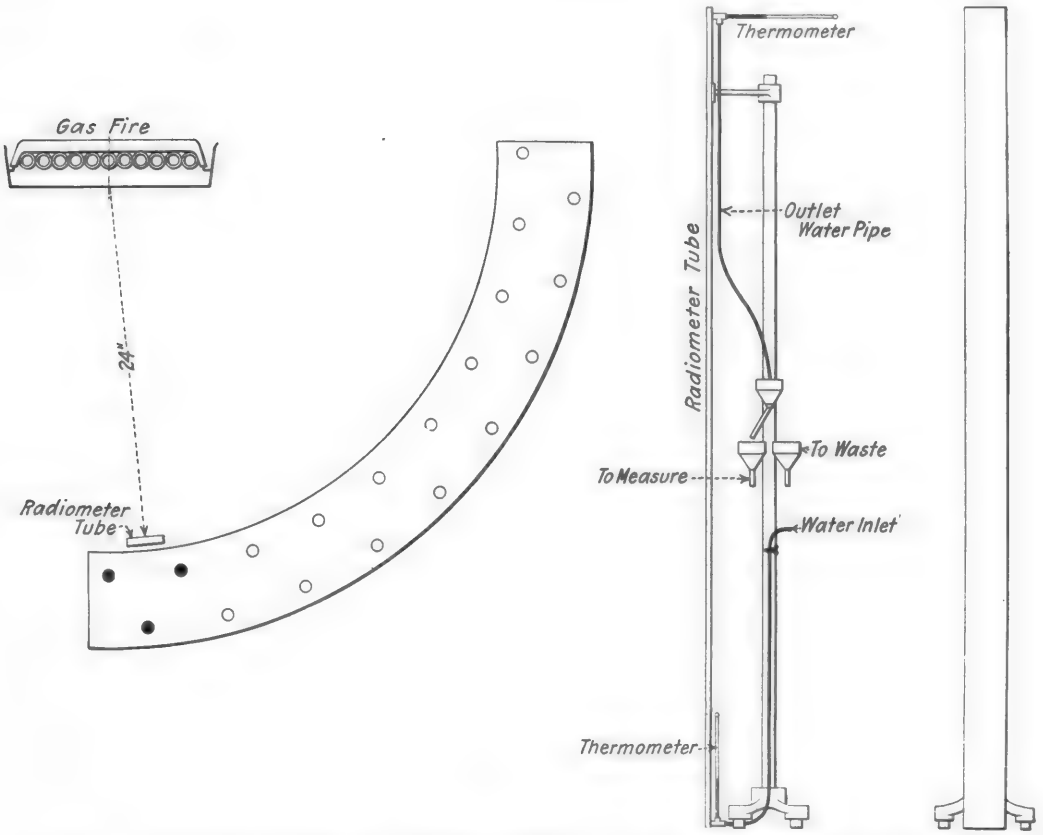

FIG. 1—WATER FLOW RADIOMETER, DESIGNED BY J. G. CLARK, FOR MEASURING RADIANT HEAT FROM GAS FIRES.

face is normal to a line drawn from its center to the center of the semi-circle.

It is apparent that if a semi-cylinder of 24-in. radius and 54 in. long be cut into a number of vertical strips, each will to some extent represent a surface similar to that provided by Mr. Clark's radiometer. Mr. Clark did not try to take the total radiation incident upon a hemisphere in front of the fire under test, being of the opinion that this does not represent the actual value of the fire from the point of view of the user.

Mr. Clark places both the fire and the radiometer on the floor level, and fills in the semi-circle of 24 in. radius in front of the fire with glazed tiles which reflect a considerable proportion of the heat known as downward radiation. Also Mr. Clark purposely neglects any rays projected above the semi-cylinder, as these are directed to the ceiling, and are of little, if any, value in practical heating.

METHOD OF TESTING WITH THE CLARK INSTRUMENT.

In making a test, the instrument is first placed in position centrally in front of the fire to be tested, and a current of water caused to flow at such a rate that its temperature is raised from 4° to 5° C. in passing through the tube; when the inlet and outlet temperatures are steady, the thermometer readings are observed and the rate of water flow is determined by experiment. A polished copper screen is then placed about 2 in. in front of the tube, and between it and the fire tested, thus shielding the blackened surface from radiation from the fire; temperature readings are again taken, the rise in temperature is again noted and deducted from the rise previously observed, giving a net rise due to absorption of radiation from the fire, from which, with the known rate of water flow, the rate of absorption can be quickly calculated.

These observations are repeated at va-

rious points around the fire, and from the mean value so obtained and the relative areas of the radiometer tube, the total radiation incident upon the cylinder is calculated, this relationship being as follows: (a) surface of radiometer 2 in. x

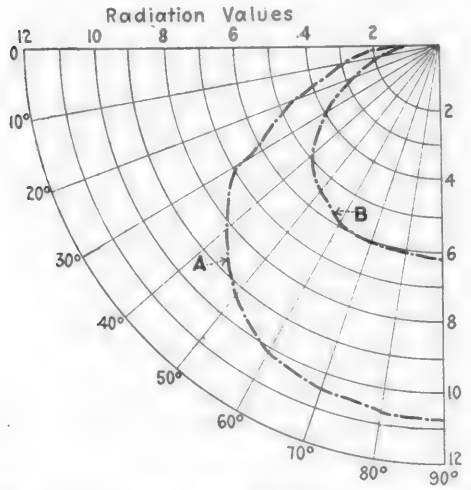

FIG. 2—DIAGRAM SHOWING SEPARATE VALUES OBTAINED FROM THE CLARK RADIOMETER IN VARIOUS POSITIONS.

54 in. = 108 sq. in.; (b) surface of semicylinder, 24 in. × 3.1416 × 54 = 4,072 sq. in.

$$\text{Ratio} = \frac{b}{a} = 37.7$$

Therefore, the mean value given by the radiometer in heat units per hour x 37.7 = total radiation per hour.

The separate values obtained from the radiometer in various positions may be plotted in the form of a polar diagram. Fig. 2 shows two curves so plotted, one from radiometer values, the other from thermopile readings.

THE GLOVER WATER FLOW RADIOMETER.

The next method of determining radiator efficiency is also a water flow radiometer used for direct absorption. In this case the apparatus is designed to absorb the total radiation incident upon a hemisphere in one operation. It consists of a hemispherical body made from two copper hemispheres, having diameters of 18 in. and 18½ in., respectively. Each hemisphere has a turned-over flange, by means of which the two are bolted together and supported. Suitable guides are placed in the small water spaces left between the two hemispheres to cause water that enters at the bottom of the apparatus to flow evenly over the whole surface before leaving by the outlet at the top. The whole is suitably mounted and the reverse sides are lagged and protected from radiation, etc. Fig. 3 illustrates the apparatus in which point 1 is the point at which cold water is admitted, a thermometer at 2 indicating its temperature, 3 being a hemispherical heat-absorbing surface. The heated water passes out at 4, its temperature being

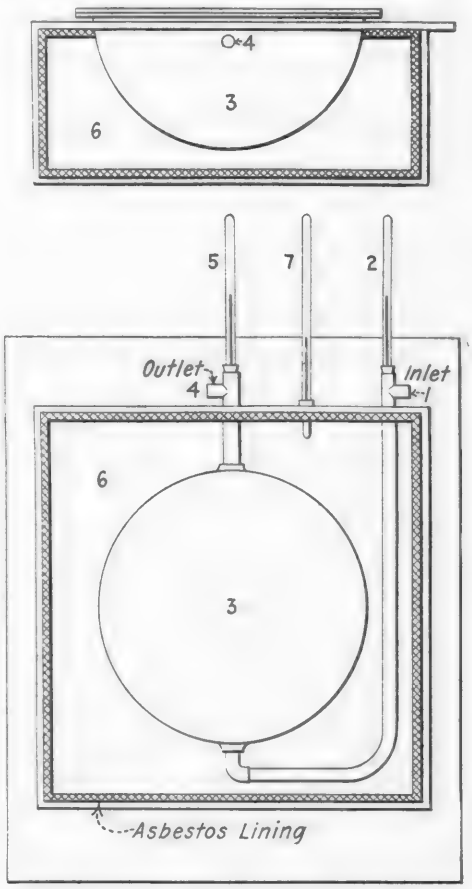

FIG. 3—GLOVER WATER FLOW RADIOMETER.

indicated by a thermometer 5. A dead air space enclosed suitably is provided at 6, the temperature of which is indicated by thermometer 7.

The manipulation of this apparatus will be clear from the particulars given for other methods. For correcting the rating readings of this instrument to the

equivalents of the Research Committee of the Institution (British) of Gas Engineers, Mr. Glover found that a correcting factor of from 1.28 to 1.32 was required, and finally the average figure of 1.3 was adopted.

THIRD SYSTEM UNDER DEVELOPMENT.

The third system for determining radiant efficiencies is now being developed in the laboratories of the Davis Co., at Luton, England. This apparatus is also of the water flow radiometer type.

In this method a water-cooled segment is used, but instead of taking separate readings at various positions, the segment is caused to slowly rotate round its vertical axes. A special duplex meter is used controlling both the supply of gas to the fire and water to the radiometer, a definite quantity of water passing with every cubic foot of gas, means being provided for adjusting the water flow to compensate for variations in temperature and pressure at which the gas is measured. In such an arrangement the difference in temperature of the water entering and leaving the radiometer may be expressed either in degrees of heat or directly in heat units per cubic foot of gas passed by meter. This latter graduation is used, but thermometers are provided for purposes of checking. Fig. 3 is an illustration of the partly developed apparatus. A delicate thermocouple having two hot and two cold junctions is used, the cold junctions being in the inlet water stream, the hot junctions in the outlet water stream, and a current is therefore set up, its intensity depending upon the difference in temperature of the two streams of water. The thermo-couple is connected to a delicate reflecting galvanometer, graduated directly into heat units per cubic foot of gas used, the whole being so arranged that a photographic record of the galvanometic indications is taken in the form of a polar diagram showing the distribution of radiation around the fire in heat units per cubic foot of gas. From this the total radiation and efficiency is easily calculated. It is proposed to take check readings with the segment rotating about a horizontal axis which will also give a further knowledge of the distribution. So far as can be stated at present, a correcting factor of 1.2 will be required with the instrument, but it is hoped to be able to introduce a permanent compensation in the meter that will give results directly comparable with the results obtained by the methods of the Gas Heating Research Committee of the Institution of Gas Engineers.

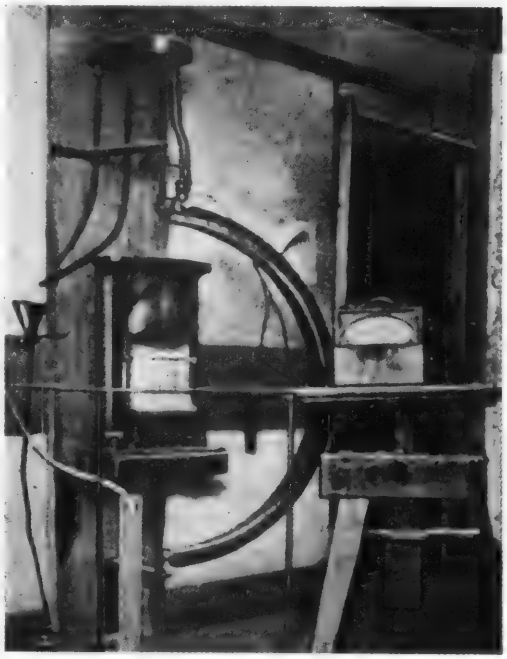

FIG. 4—NEW TYPE OF WATER FLOW RADIOMETER BEING DEVELOPED BY THE DAVIS COMPANY.

Radiator Traps and Test Data

By L. M. Arkley, M. Sc.,

Lecturer in Mechanical Engineering, University of Toronto.

In order to test the comparative efficiencies of several well-known makes of radiator traps, a series of experiments were conducted recently at the University of Toronto, the results of which are reported in *The Sanitary Engineer* of Toronto:

The testing apparatus consists essentially of a standard type of radiator having 60 sq. ft. of radiating surface and which is connected to the steam pipes in the same way as when set up for actual service. A mercury manometer is attached to the inlet pipe to register the pressure of the steam entering the radiator, while a thermometer in the same pipe can be used to indicate the temperature when desired. To the outlet pipe is attached a radiator trap E, a tank B, in which is collected the condensed steam from the radiator, a glass condensing coil, and a glass jar A, which condenses and collects any steam that may pass the trap.

There is an advantage in having the condensing coil and jar A of glass, as, during the test, the rate at which the steam is passing the trap may be noted and the completeness of condensation verified.

The desired vacuum was indicated on gauge C, and was obtained by connecting the apparatus to a vacuum pump as shown.

The object of test was to determine:

(a) Whether the traps performed their main function, namely, that of allowing all water of condensation to pass from the radiator without letting steam pass as well.

(b) The temperature efficiency of radiator.

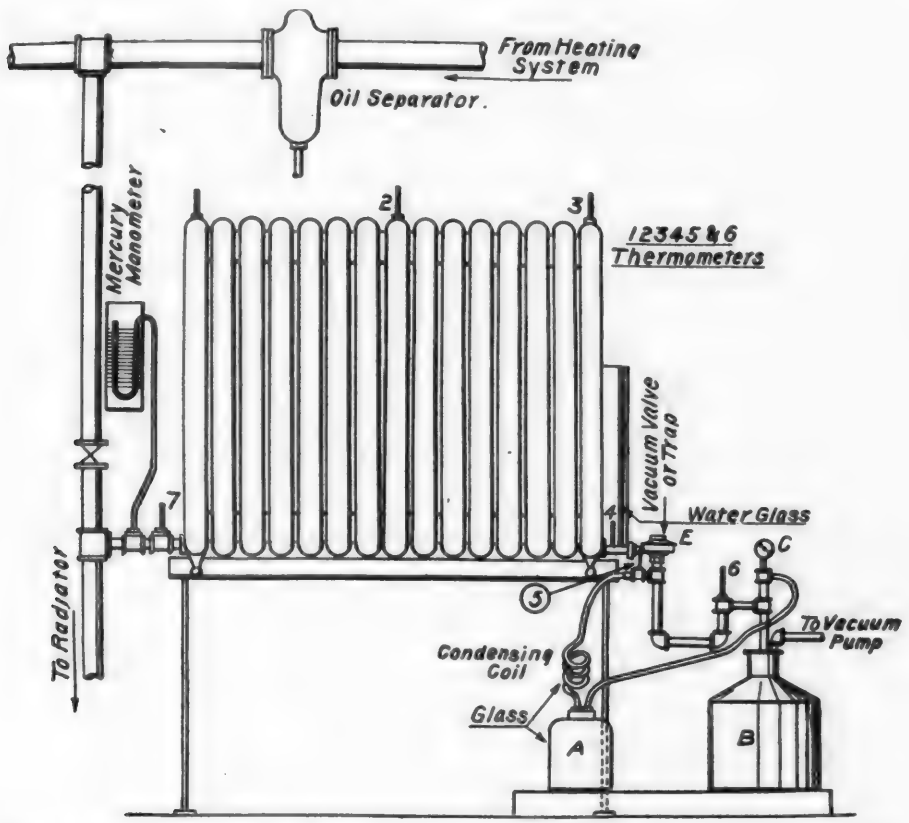

FIG. 2—ARRANGEMENT OF APPARATUS FOR TESTING RADIATOR TRAPS.

(c) Whether all air was removed from the radiator by the trap.

(d) Whether the traps performed their functions without noise.

METHOD OF MAKING TESTS.

Before starting the tests, steam was turned on the radiator and the system allowed to heat up to its normal working condition; after this, readings of temperatures and pressures were taken at intervals of ten minutes for a period of two hours. If any water had collected in the radiator during the test it was drawn off and weighed.

By referring to Fig. 2, it will be seen that tanks A and B are so connected that they are always under the same vacuum or pressure, the water-leg preventing steam from passing to the tank B. Therefore, if any steam passes the trap, it will find its way to the condensing coil and from there to the tank A. The weight of water in B represents the steam condensed in the radiator, while the water in A, after the proper corrections has been made, represents the steam that has passed the trap.

METHOD OF COMPUTING RESULTS.

In order to get the true value of the steam passing the trap, a correction must be made to the quantity caught in tank A, because a certain amount of the water in the radiator, which would remain as water while under the pressure in radiator, would burst into steam after passing to the lower pressure beyond the trap. The following method will give a close approximation to what this correction should be:

Let A = the number of pounds of water caught in tank A.

Let B = the number of pounds of water caught in tank B.

Let r = the heat of vaporization of one pound of saturated steam under vacuum.

Let X = temperature of water at thermometer No. 4.

Let Y = temperature of steam corresponding to vacuum.

Let C = correction, i. e., the number of pounds of water to be deducted from A.

Let E = net weight of steam passing trap.

LOG SHEET OF DATA—FOR TESTS 2 TO 9.

No. of test.	Values given.	Time.	Pressure ins. of mercury.	Vacuum ins.	Temperatures, Deg. F. 1	2	3	4	5	6	Room.	Name and type of trap.	Aver. temp. of radiator, deg. F.	Temp. efficiency of radiator, per cent.	Steam condensed in radiator, lbs.	Steam passed by trap, lbs.	Steam passed by trap, per cent.
2	Min.	10:11	2.7	9.0	214.0	215.0	213.0	212.0	182.0	180.0	100.0	*Webster	....	....	....	....	....
	Max.	to	3.8	9.0	216.0	217.0	215.5	215.0	191.0	187.0	106.0	Sylphon	....	....	....	....	....
	Aver.	12:11	3.05	9.0	215.0	215.6	214.4	213.8	188.5	185.0	102.0	Trap	215.0	99.1	38.5	0.00	....
4	Min.	10:40	2.7	9.0	214.0	215.0	214.5	215.0	183.0	190.0	....	*D. G. C.	....	....	....	....	....
	Max.	to	3.1	10.5	215.0	216.0	215.0	216.0	194.0	198.0	....	Disc	....	....	....	....	....
	Aver.	12:40	2.92	9.6	214.6	215.5	215.0	215.7	190.6	194.0	....	Trap	215.0	99.2	43.5	0.54	1.22
5	Min.	20:8	2.7	10.0	213.5	214.5	214.0	214.5	189.0	192.0	98.0	*"Vento"	....	....	....	....	....
	Max.	to	3.3	10.0	215.0	215.0	215.0	215.0	190.0	193.0	110.0	Thermostatic	....	....	....	....	....
	Aver.	40:8	2.96	10.0	214.0	215.0	214.2	215.2	189.7	192.4	107.0	Trap	214.4	98.94	46.5	0.58	1.21
6	Min.	15:5	2.1	9.0	213.0	214.0	213.0	212.0	186.0	182.0	106.0	*"Welo"	....	....	....	....	....
	Max.	to	4.2	10.0	217.0	217.5	217.0	215.0	189.0	183.0	107.0	Low pressure	....	....	....	....	....
	Aver.	3:55	3.03	9.16	214.7	215.4	214.6	212.5	188.5	182.0	106.7	Trap	214.9	99.1	36.0	0.00	....
7	Min.	10:29	4.5	8.0	217.0	218.0	216.0	207.0	172.0	173.0	95.0	*"Sarco"	....	....	....	....	....
	Max.	to	4.6	10.0	217.5	218.25	217.0	217.25	194.0	197.0	101.0	".....	....	....	....	....	....
	Aver.	12:29	4.54	9.32	217.3	218.10	216.9	214.5	181.0	180.2	99.0	.....	217.4	99.2	41.0	0.25	0.6
8	Min.	2.25	3.1	7.5	215.0	215.0	214.5	215.0	191.0	183.0	97.0	Marsh	....	....	....	....	....
	Max.	to	5.6	9.5	219.0	220.0	219.0	219.0	192.0	188.0	104.0	*Reflex	....	....	....	....	....
	Aver.	4:25	5.08	9.1	218.1	219.1	218.2	217.5	191.8	186.0	101.4	.....	218.5	99.3	39.5	0.03	....
9	Min.	10:12	3.9	9.0	217.5	217.0	215.6	216.0	180.0	176.0	75.0	*Dunham	....	....	....	....	....
	Max.	10:12	4.0	10.5	217.5	217.0	216.0	216.0	184.0	190.0	79.0	No. 1 Radiator	....	....	....	....	....
	Aver.	10:12	4.0	10.0	217.5	217.0	215.8	216.0	182.0	187.5	76.0	Trap	216.8	99.2	39.1	0.00	....

*All the traps tested operated without noise, and none of them allowed air or water to gather in the radiator.

LOG SHEET OF COMPLETE DATA TAKEN IN LEADING TEST, NO. 1

Time, P. M.	Steam pressure, ins. of mercury.	Vacuum, ins.	Temperatures in Degrees F. 1	2	3	4	5	6
2:48								
2:50	2.2	10.0	214.0	214.5	214.0	214.0	187.0	190.0
3:00	2.2	10.0	214.0	214.5	214.0	214.0	189.0	192.0
3:10	2.2	10.0	214.0	214.5	214.0	214.5	190.0	192.0
3:20	2.1	10.0	213.5	214.5	214.0	215.0	191.0	193.0
3:30	2.1	9.5	213.5	214.5	214.0	214.5	190.0	192.0
3:40	2.1	10.0	213.5	214.5	214.0	214.5	191.0	193.0
3:55	2.1	10.0	213.5	214.5	214.0	214.0	189.0	191.0
4:05	2.1	10.0	214.0	214.5	214.0	214.5	190.0	191.5
4:15	2.4	10.0	214.5	215.0	214.0	215.0	190.0	192.0
4:25	2.5	10.0	214.0	215.0	214.5	215.0	190.0	193.0
4:35	2.5	10.0	214.0	215.0	214.5	215.0	190.5	193.0
4:45	2.5	9.5	214.0	215.0	214.5	215.0	191.0	193.0
4:48	2.5	10.0	214.0	215.0	214.5	215.0	191.0	193.0
Average values	2.27	9.9	213.9	214.6	214.1	214.6	190.0	192.0

Total period of test ..... = 2 hrs.
Average temperature of radiator ..... = 214.2° F.
Temperature corresponding to pressure in radiator ..... = 215.6° F.
Temperature efficiency of radiator ..... = 99.3%
Name of trap ..... Webster water seal motor.
Steam condensed in radiator ..... = 38.5 lbs.
Steam passed by trap ..... = 0.61 lbs. = 1.58%
No air or water collected in radiator.
Operation of trap noiseless.

Then $C = \frac{X - Y}{r} \times B$ and $E = A - C$.

The above correction, while not exact, is quite close enough for practical purposes, and as it has been applied to each valve tested, the comparison should be fair.

The temperature efficiency of the radiator is defined as the average temperature of the radiator divided by the temperature of saturated steam corresponding to the pressure in the radiator. The temperature efficiency gives a very good indication of the quantity of air being trapped and held in the radiator sections. For instance, if the temperatures as read from thermometers 1, 2 and 3, Fig. 2, are nearly equal, and not far below that corresponding to the steam pressure, it shows that steam is filling each section and therefore air must be absent. In the following tabulation the first test is given complete; in the others, only the minimum, maximum and average values are given for the pressures and temperatures, and the final results.

PURPOSE OF TESTS.

These tests were made primarily for the purpose of satisfying the writer as to the value of radiator traps which he has had occasion to specify at different times in connection with the design of low pressure heating systems. Numerous inquiries along this line from architects and heating engineers would indicate that the question is a live one.

It must be remembered that there are other important features connected with radiator traps which cannot be decided by laboratory tests, for example, mechanical construction, on which depends the life of the valve and its seat. The lift of the valve from its seat and the shape of both valve and seat determine its likelihood to clog on account of scale or dirt coming from the radiator. The ease with which the traps may be cleaned and kept in running order is also a very important feature. Mechanical knowledge and good judgment on the part of the purchaser should enable him to choose the best trap from a mechanical standpoint, but the length of life and other such questions can only be determined by comparing the action of traps operating over long periods of time under similar conditions.

The writer wishes to acknowledge suggestions and help given by Professor R. W. Angus, of the Department of Mechanical Engineering of the University of Toronto, and also the hearty co-operation of the manufacturers who furnished the traps tested.

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THE importance to the heating trade of watching the course of pending legislation in the various State legislatures does not, ordinarily, appeal to the average heating man, but in the light of the information brought out at the recent convention of the master steam fitters' association, it is evident that a very real danger exists in the passing of drastic and ill-considered laws relating especially to the operation of heating plants. It was brought out, for instance, that a large mass of this sort of legislation was introduced during the past winter and one of the principal reasons given for its failure to pass was the fact that most of the legislatures were congested with bills. In a few cases the activities of the different associations were effective in rooting out "jokers" and "strike legislation," but in most of the cases cited the trade appeared to be entirely unaware of the dangers that lay before it.

One of the commonest types of bills coming under this heading were those providing for State inspection of steam boilers, where provision is made for State boards of inspection and requiring boilers to be inspected periodically and a fee to be paid. It is well understood that such a law is intended to apply to power boilers, but where the pressures carried are not mentioned, the passage of such bills, as was tersely stated, "would mean a large decrease in steam and hot water heating jobs in favor of furnace work, especially in the smaller jobs."

One of the most pernicious types of bill is that which provides that all operators of steam boilers over a certain size, and frequently the exemption is very small, must not only be examined by a State board, but must be licensed by a State board to operate a boiler. A number of instances were found where the wording of the bill would require every flat or apartment house which uses steam heat to employ a licensed engineer or fireman to run its boilers.

Still another class of legislation would empower a State board, and in Pennsylvania, for instance, a local board in each city, to pass arbitrarily upon the safety of each installation before the plant could be accepted and placed in use.

It will also be a matter of information to many to know that where there is no State law on the subject a municipality can regulate these things in the same way as it provides smoke ordinances and similar restrictions.

Fortunately, there is little likelihood of further objectionable legislation until 1917, as most of the legislatures have adjourned until that time, but it is predicted that unless preventive measures are taken in the meantime the trade "can depend upon it that sooner or later every legislature in this country is going to have something to say about boilers and inspection and about insurance."

THE CONSULTING ENGINEER

The Consulting Engineer" is prepared to reply, in this department, to any questions which our readers may ask regarding problems connected with the design and installation of mechanical equipments of buildings.

CONDUCTED BY IRA N. EVANS, C. E.

51—Data on Overhead Steam Heating.

QUESTION: Can you inform us where we may get a book of plans or other information treating on one and two-pipe overhead steam heating plants? What we want is a book covering this system in detail so that we can arrange our piping correctly on a system carrying about 3,500 sq. ft. of radiation using exhaust steam.

ANSWER: A description of the Mills sys-

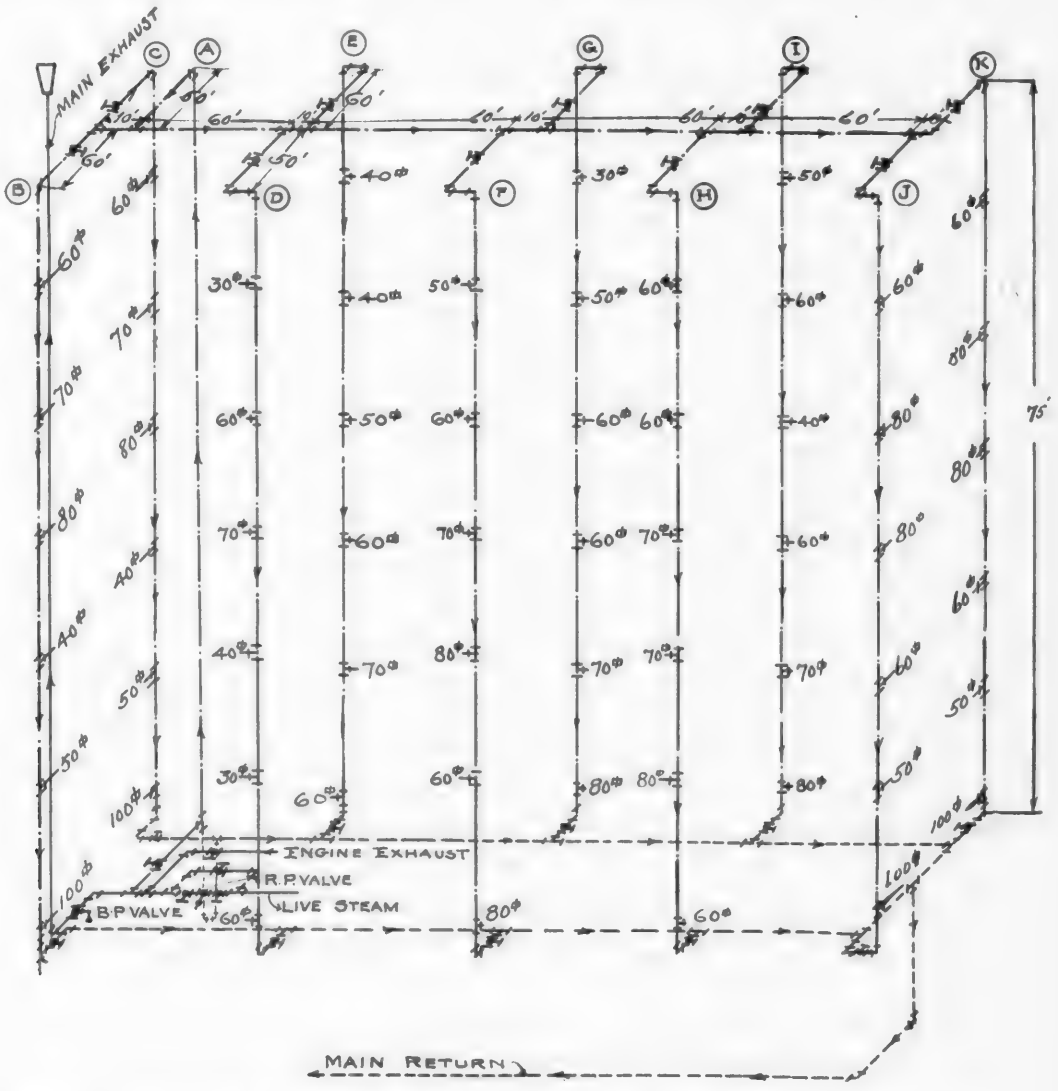


FIG. 1—SKETCH SHOWING ARRANGEMENT OF MILLS SYSTEM OF HEATING.

tem can be found in Mills' book on heating. Although this book is out of print, it may be had in many of the public libraries The Mills system is merely an overhead system, with single pipe riser drops. One of the best publications on pipe sizes is a pamphlet published by the Positive Differential System Company, of New York. By using the table contained in this pamphlet, giving the pounds steam for each size of pipe per 100 ft. of length for every drop in pressure in ounces, all that is necessary is to figure the pounds of steam required at each branch and take from the table the size pipe for the distance and discharge, marking the drop in pressure from one connection to another. When the trial sizes are completed, the size pipe may be adjusted so that for each required discharge at each outlet there shall be the same drop in pressure from the source.

Fig. 1 is an isometric sketch of what is known as a Mills system of piping. The figures give the lengths of piping and Table 1 will be used for determining sizes.

This table was compiled by J. A. Donnelly and the writer has changed the square feet of radiation to pounds steam per hour as radiation is used under such varying conditions that if the rates are reduced to pounds of steam per hour, the table becomes universal for all systems and conditions under which radiation operates. For higher pressures the pipe sizes would be too large.

Assuming a maximum pressure of 5 lbs., the radiation will give off

$(220 - 70) \times 1.7 = 255$ B.T.U. per sq. ft.

Allow 20% for radiation and initial heating up, and the condensation will be 0.3 lbs. per square foot of surface. As the piping is laid out so that every radiator is the same distance from the source or supply and return point of the system, the risers should have practically the same drop in pressure.

Each riser is 75 ft. long and assuming one-half the length and lengths of runout, we will assume lengths as follows for the total radiation on each.

Risers C, E, G, I, K will be 100 ft. long.
Risers B, D, F, H, J will be 110 ft. long.

TABULATION OF SIZES OF RISERS AND DROP IN PRESSURE.

Riser.	Surface, sq. ft.	Lbs. steam per hr.	Length, ft.	Drop, oz., 2-in.	Drop, oz., 1½-in.
B	400	120	110	2.11	11
C	400	120	100	1.92	10
D	290	89	110	1.18	6
E	380	114	100	1.9	9.6
F	400	120	110	2.11	11
G	350	105	100	1.7	8
H	340	102	110	1.9	9
I	360	108	100	1.7	8.5
J	430	129	110	2.11	11.8
K	430	129	100	2	10.8
A	3,780	1,136	200	....	....

Drop in Pressure in Mains.

	Lbs. steam per hr.	Diam. pipe, ins.	Drop, oz.	Diam. pipe, ins.	Drop, oz.
K to I (70 ft.), supplying risers J and K	258	2½	1.9	3	0.7
I to G (70 ft.), supplying risers H, I, J, K	468	3	2.14	3½	0.93
G to E (70 ft.), supplying risers F, G, H, I, J, K	693	3½	2.24	4	1.05
E to A (70 ft.), supplying risers D, E, F, G, H, I, J, K	896	4	1.6	4	1.6
Total drop in supply mains			7.88		17.10
A (200 ft.)	1,136	4	7.9	5	2.16
Riser with max. drop (J)	5	1½	11.8	2	2.11
Return same as main supply	...	...	7.88	...	8.55
Total pressure drop			35.46		17.10

Note: Pressures and drops were interpolated in some cases.

The small sizes will give a drop of 2.22 lbs. and large ones 1.1 lbs.

Risers A and C will not be included as the drop will be less than the others. The sizes, however, will be A to B, C (10 ft.), 240 lbs. steam per hour, 2-in. pipe, 0.77 oz. drop.

DISCHARGE OF STEAM MAINS IN POUNDS OF STEAM PER HOUR

SHOWING DROP IN PRESSURE IN OUNCES PER 100 FT. RUN: NOMINAL SIZES PIPE USED.

MEAN PRESSURE 2 LBS. GUAGE

VELOCITY FT. PER SEC.	10 FEET		20 FEET		30 FEET		40 FEET		50 FEET		60 FEET		70 FEET		80 FEET		90 FEET		100 FEET		110 FEET		120 FEET		130 FEET	
SIZE MAIN	DROP OZ	STEAM PER HOUR LBS	DROP OZ	STEAM PER HOUR LBS	DROP OZ	STEAM PER HOUR LBS	DROP OZ	STEAM PER HOUR LBS	DROP OZ	STEAM PER HOUR LBS	DROP OZ	STEAM PER HOUR LBS	DROP OZ	STEAM PER HOUR LBS	DROP OZ	STEAM PER HOUR LBS	DROP OZ	STEAM PER HOUR LBS	DROP OZ	STEAM PER HOUR LBS	DROP OZ	STEAM PER HOUR LBS.	DROP OZ	STEAM PER HOUR LBS.	DROP OZ.	STEAM PER HOUR LBS
1- INCH	.40	7.5	1.6	14.7	3.6	22.2	6.4	30.	10.	37.2	14.4	44.4	19.6	52.2	25.6	59.4	32.4	67.2	40	74.4						
1-1/4 "	.29	11.7	1.16	23.1	2.61	34.8	4.64	46.5	7.25	58.2	8.28	69.6	11.4	81.3	14.72	93.	23.5	105.	29	116.4						
1-1/2 "	.2	16.5	.8	33.6	1.8	50.4	3.2	67.2	5.	84	7.2	100.8	8.8	117.6	12.8	134.4	16.2	151.2	20	168.						
2 "			.48	60.	1.08	80.	1.92	120.	3.	150.	4.32	180.	5.88	210.	7.68	240.	9.6	270.	12.	300.						
2-1/2 "					.75	139.5	1.34	186	2.1	232.5	3.02	279	4.1	325.5	5.37	372.	6.6	418.5	8.4	465.						
3 "					.56	200.7	1.00	267.6	1.56	334.5	2.25	401.4	3.06	468.3	4.00	535.2	5.04	602.1	6.25	669.						
3-1/2 "							.85	364.8	1.33	456.	1.8	547.2	2.6	638.4	3.4	729.6	4.3	820.8	5.31	912.						
4 "							.66	480.	1.04	600.	1.5	720.	2.04	840.	2.66	960.	3.37	1080.	4.16	1200.						
5 "							.48	744.	.76	930.	1.08	1116.	1.37	1302.	1.92	1488.	2.43	1704.	3.0	1860.						
6 "									.57	1341.	.82	1609.2	1.12	1677.4	1.47	21456	1.86	2413.8	2.3	2682.						
8 "											.56	2862.	.66	3339.	1.00	3816.	1.26	4293.	1.56	4770.	1.89	5262.	2.25	5724.		
10 "														5208.	.75	5952.	.95	6696.	1.18	7440.	1.43	8184.	1.7.	8928.	2.	9672.
12 "															.60	8592.	.76	9666.	.94	10740	1.14	11814.	1.36	12888.	1.70	13962.
14 "																	.63	13149.	.78	14610.	.95	16071.	1.13	17532.	1.32	18993.
16 "																	.53	17172.	.66	19080.	.80	20988.	.93	22896.	1.2.	24804.

50—Figuring Tank Sizes.

QUESTION: I am often asked the question regarding tank sizes; that is, what size tank would be required for a certain number of fixtures. I have failed to find any information of this kind in books and am taking the liberty of asking you if you have any information on this matter or can tell me where I can get the information. How much hot water is ordinarily used for a bath? How much for a lavatory, etc.?

ANSWER: There are no set rules for this. A 30-gal. tank is generally considered sufficient for five people; that is, one bath and two basins. In large buildings a shower generally requires 6 gal., a bath 10 gal. and a wash basin 1 gal. When they are set in batteries the frequency of their use is taken into account, which is governed by circumstances in each individual case.

Where showers are in a battery and are used altogether, the number of baths should be multiplied by 6 gal. and, if there is a long interval between times of use, the storage tank can be made so as to take care of the sudden draft and the heater made of only sufficient capacity as to furnish the hot water over a longer period by continuous operation.

Suppose we had 10 showers and 60 men would have to use them at a certain hour in the day. This would require 360 gal. of hot water in perhaps the course of one hour. As the tank heater could run 10 hrs. to heat this water, a 400-gal. tank could be used and a heater installed only large enough to heat 40 or 50 gal. per hour.

Instantaneous heaters are frequently used for such service, but they require a large amount of power over a short interval of time and are only practicable where power in large quantities is available.

Current Heating and Ventilating Literature.

Under this heading is published each month an index of the important articles on the subject of heating and ventilation that have appeared in the columns of our contemporaries. Copies of any of the journals containing the article mentioned may be obtained from THE HEATING AND VENTILATING MAGAZINE *on receipt of the stated price.*

FUTURE DEVELOPMENT—

Some Future Developments in Heating and Ventilation. A. H. Barker. Problems of this science. 6,500 w. Archt., Lond.—May 21, 1915. 40c.

GAS HEATING—

Cost and Method of House Heating by Gas. F. R. Hutchinson. Ills. 3,000 w. Gas Age—June 1, 1915 20c.

OZONE—

Ozone—An Aid to Factory Ventilation. V. D. Greene. How foul air and offensive odors can be cheaply overcome. 4,000 w. Engng. Mag.—July, 1915. 40c.

Air Permeability of Building Materials.

As the result of tests made by the laboratory of technical physics of the Technical High School at Munich and reported by Hans Freiherr von Thielmann in Gesundheits-Ingenieur, coefficients have been developed for the permeability of certain building materials which have been placed on the market in recent years, notably chalky sandstones. In an abstract of this article published in the Journal of the American Society of Mechanical Engineers for August, 1915, the arrangement of the testing apparatus is shown and described. The test consisted briefly in exerting an air pressure of about 100 mm. of water on one side of the material and measuring the air that passed through.

The material investigated was of various thicknesses, on the average 60 mm. The part of the stone facing the outside atmosphere had often to be limited to 10 by 10 cm. because with a larger area of outflow the air velocities in the meter and drying flask were too high, which created undesirable disturbances, such as the carrying over of particles of calcium chloride, used to keep moisture away from the material, into the piping. The duration of the test was on the average 30 minutes and the air temperature about 20° C.

Each test was, as a rule, repeated three times and the data reported represent an average of all three tests. The Lang law was sometimes used in the calculations; viz., that the volume of air flowing through is inversely proportional to the thickness of the material.

The values obtained are shown in the second column of the accompanying table. From them is calculated the coefficient of permeability c, under the assumption that the volume of air Q flowing in a unit of time through an area F of stone is inversely proportional to its thickness d, and directly proportional to the gage pressure p. Under this assumption the volume of air flowing through the stone is defined by the equation

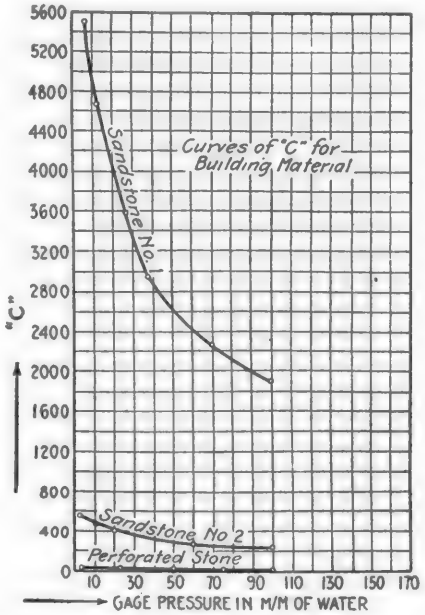
$$Q = c\ p\ F$$

and c indicates therefore the volume which will flow per hour through 1 sq. m. of stone surface, 1 m. thick, at a gage pressure of 1 mm. of water (the table, because of lack of space, is given in an abbreviated form). The "perforated stones" were bricks having four cylindrical perforations of 4 cm. in diameter, running parallel to their long edge, 12 cm. long. In addition to tests at the constant gage pressure of 100 mm., a series of tests was also made at variable pressures, data of which are given in the original article in a table. From these data,

DATA OF TESTS ON AIR PERMEABILITY OF BUILDING MATERIALS.

Material	Q – 1 per hr.	c (average value)
Sandstone	5,680,000	
	3,715,500	
	3,136,500	997
Chalky sandstone.....	76,060	
	39,170	
	29,060	14.4
	4,890	
	4,760	
	2,670	1.23
Perforated brick.....	36,640	
	32,720	
	7,474	
	4,547	5.83
Hand-made brick (hard burned)	7,540	2.26
Machine-made brick....	8,346	
	6,820	
	1,915	
	1,880	1.42

the coefficient of air permeability c was calculated and is shown in the accompanying curves. As has already been noticed by Gosebruch, c is not constant but increases as the pressure decreases, this increase being considerably greater with goods of porous material than with tougher materials. The decrease of air permeability with an increase of the pressure differences is to be explained by the fact that the rapid growth of frictional resistance at greater pressure



CURVES SHOWING AIR PERMEABILITY OF THREE BUILDING MATERIALS.

differences, and hence increased velocity of flow, produces a strong reduction of the motion of air through the material in the case of materials with very large pores. There is, in addition to that, the influence of flow produced by the phenomenon of expansion and turbulent motion in the hollows which affects still more the air permeability of the material at higher pressures.

An Architect on Modern Ventilation Ideas.

Some idea of what the architect thinks of the trend of thought in recent years regarding the art of heating and ventilating is given in an address by Charles Sumner Kaiser, of San Francisco, before the American School Hygiene Association. His comments display a close observation of recent developments in this connection:

After a full generation of our respected but obsolete heating and ventilating standard, we have come at last to see that the chief physiological purpose of ventilation is not merely to provide air to breathe, but to aerate the whole body and aid its nicely balanced heat mechanism in maintaining the constant temperature upon which life depends. We have found that the precise and overheated product of our "standard" heating plant tends precisely against this vital purpose, while the environment that promotes it is the moving, changing, relatively humid open air. Upon this better realization are based three interesting and divergent lines of progress—in mechanical ventilation, in the application of the "fresh air" idea and, finally, in the approach to a higher and truer ideal in heating science.

Our older system has had its own line of development, in air-washing, moistening and regulating apparatus, chiefly, and is now facing almost a revolution. Hygienists of reputation have asserted that the purity, temperature, humidity and movement of the air can be fully controlled by such mechanical means, and hence that health-giving conditions for schools can be most efficiently realized by closing the outdoor supply, sealing the windows, and mechanically rewashing, recirculating and using practically the same air over and over again. Such a system has been installed in the new Wethersfield Avenue School, Hartford, capable of operating with only 10% of outdoor air. If this method is a success, mechanical ventilation will indeed have reached its logical, if somewhat startling, conclusion.

At the farthest extreme from this is the happy and beneficent "Open Air School," with its direct recourse to nature. Here temperature is secondary so long as the air is fresh, while the heat economy of the body is promoted in all climates by suitable clothing, feeding and physical activities. There is every reason for the wide favor this school is gaining. It seems to offer the only effective invitation to that vague wholesome outdoor quality which still eludes capture at the hands of ventilating engineers, and which is still missed in the compromises frequently attempted.

Each of these methods, in its own way, looks back to nature. Neither, however, quite achieves her high ideal, for a complete "natural standard" of warmth and air has not been adequately formulated. The air of nature is most vitalizing and agreeable, not merely when cool and moving, but when heat energy is streaming through it on the rays of the sun. As with an open fire, this radiance brings physical comfort with air temperatures, 8° to 12° lower than where heat is carried by the air itself, with marked effects in physical and mental stimulation. Nature's method, accordingly, gives the body adequate heat without depriving it of really fresh air. At the same time it exhibits that complete separation of heating and ventilating functions which is so much desired and theorized about, but which is almost never found in practice.

It is precisely in the unnatural combination of these two functions, in fact, that all our troubles arise. Our unsanitary dust-decomposing "radiators," so called, are designed chiefly to heat the air by convection and circulation. Unless this air itself is overheated enough to counterbalance the heat losses through the walls and windows of rooms, such surfaces will remain cold and must absorb heat from the occupants, inducing chill. This is aggravated by the relative dryness of the overheated air and the consequent rapid evaporation of the surface moisture of the body. For both comfort and health, therefore, the natural principle seems to be that heat should not be carried primarily by the air, but should be imparted in some measure to the building itself. Our ideal, in other words, demands that the radiant heat of the sun shall be brought indoors.

POSSIBILITIES OF RADIANT HEAT.

Though the idea is far from new, the possibilities of radiant heat have hardly been touched in modern times. Undoubtedly the most splendid examples of radiant heating were the Calidaria of the ancient Roman baths, in which the hot gases from fires were carried under the floors and upward through hollow walls. The same method seems to have been used in some Roman palaces for comfort alone. After the lapse of centuries, however, this same principle has reappeared on a large scale

in the "Hot Panel" system of heating, originally devised by A. H. Barker, B.Sc., of the University College, London, and applied by Captain H. Riall Sankey, R.E., in some important buildings at Liverpool—in particular, the Royal Liver office buildings and the Midland Adelphi Hotel. Here the heat radiating elements have taken the form of hot wall panels, floor borders, cornices, and even the ceilings of rooms; and the results are said to have exceeded all expectations. The plane radiating surfaces are proved to be much more effective than ordinary "radiators"; their temperature is kept relatively low; the lower air temperature permitted requires less fuel to produce and involves less waste by radiation through unheated walls and windows.

While these installations were probably expensive, the fundamental idea is simple, and it can and doubtless will be simply applied as soon as the subject is better understood. John V. Van Pelt's suggestion of foot-warming plates for open air schools is a step in this direction. Cheap electric current would here offer the most attractive possibilities. When fully developed, radiant heating should not only prove invaluable for schools, but it is the one kind of heating that is perfectly adapted to hospitals and sanitoriums.

In view of this advance in heating science, the pursuit of a natural, healthful ideal by the means now employed seems quite futile. For this purpose nature must be more closely studied, and our artificial methods profoundly modified. Measured by the same ideal, the open air school itself accepts a too stern and cheerless natural standard—fresh air without the full pervading warmth of sunshine. This, however, may be incidental, for the spread of this splendid type of school is doubtless far less retarded by the indifference to the fresh air ideal than by the prevailing sedentary character of school work; all of which leads to the conclusion that a natural ideal of warmth and air must involve likewise more natural and suitable school occupations.

New York School of Heating and Ventilation.

The class in heating and ventilation, conducted by Charles A. Fuller under the name of the New York School of Heating and Ventilation, will open for the fall season in Room 511, World Building, New York, the first week in October. Sessions will be held thereafter weekly on Monday evenings at 7:30 P. M. The secretary of the school is George G. Schmidt, 132 Nassau Street, New York.

The Electric Fan as an Adjunct to the Heating System.

The ordinary electric fan can be effectively used to increase the efficiency of the heating system of a building in cold weather. In connection with steam heating a fan placed upon the floor in such a position that it blows the cool air against the radiator will materially increase the heat convection from the radiating surfaces. Placed in the cold-air intake of a hot-air furnace it will not only cause the rooms to heat more quickly, but will increase the efficiency of the furnace and improve the ventilation of the building.

A series of tests were conducted by two senior students of the University of Missouri to ascertain the saving in coal effected by the use of the electric fan as above described. The building tested was an eight-room frame dwelling, approximating in design, construction and arrangement the average American home, and while the figures obtained apply only to the house tested, nevertheless, they will furnish an approximate guide to the possible saving in homes by the use of a fan.

In the tests, the amount of coal necessary to maintain the house at a uniform temperature of 71° F. for various outdoor temperatures was determined both with and without the fan. The method of firing, the rate of stoking and the setting of the dampers were the same for all the tests. The coal used was a hand-picked, Illinois lump coal, with an average heating value of 13,500 B. T. U. per pound. The interval between stokings was arbitrarily chosen as 15 minutes. Readings were taken of the amount of coal fired, outdoor temperature, temperature in cold-air duct, velocity of air in cold-air duct, temperature of air leaving registers, room temperatures, watts input to the fan and line voltage.

Each test was begun with the average house temperature in the neighborhood of 71° F. Readings were taken every fifteen minutes until the average house temperature had remained constant for at least an hour. If this average temperature was above 71° F., the amount of coal fired every fifteen minutes was reduced, and if below 71° the amount of coal fired was increased. Thus the proper amount of coal required to maintain the average house temperature at 71° was determined for various outdoor temperatures with and without the fan running.

From data tabulated from a test made with an outside temperature of 15° F., it was observed that, although the outdoor temperature had increased 1° in the second

part of the test with the fan shut off, the furnace required 8 oz. more coal every fifteen minutes to maintain an average room temperature of 71.3°. The tests were repeated for outdoor temperatures of 4°, 25° and 35° F., with the results shown in the table.

RESULTS OF TESTS AT VARIOUS TEMPERATURES.

Outdoor Temp'ture, Deg. F.	Lbs. of Coal Fired Every 15 Mins. With Fan.	Without Fan.	Lbs. of Coal Saved in a Day of 16 Hrs. by Using Fan.
4	6.0	6.5	32
15	4.0	4.5	32
25	2.5	3.0	32
35	2.0	2.25	16

With coal at $4 per ton, the amount saved per day in the cost of coal was 6.4 cts. With electricity at 6 cts. per kw.-hr., the cost per day of running the fan, which consumed 47 watts, was 4.6 cts. The net saving obtained by using an electric fan in the cold-air duct of a furnace was, therefore, 1.8 cts. per day at the above prices for coal and electricity.—Percy W. Gumaer, in the *Electrical World*, abstracted by *Engineering Digest*.

Suggestions for Installing and Testing Factory Exhaust Systems.

Further details of the operation of the Illinois blower law, contained in the recent report of the Illinois chief state factory inspector, Oscar F. Nelson, state that the work connected with the so-called dusty trades, such as employment around metal polishing, buffing and grinding machinery, was considered so hazardous an occupation that life insurance companies used to refuse to accept as risks the men engaged in the above mentioned trades. The introduction of properly designed and effectively operated exhaust systems in connection with the wheels and belts, thereby removing the dust and allowing the men to work in a pure atmosphere, has so far corrected the danger of disease as to make these men acceptable insurance risks in most companies.

Referring again to the construction of hoods that cover the wheels, a little clearer idea is given in the words of the report, which states that "one of the greatest mistakes in the construction of exhaust systems arises in the construction of hoods that cover the wheels. It seems to be a habit to install hoods with the branch pipe connecting to said hood in the rear of the wheels at a distance of from 18 to 24 in. from the point of work on the wheels. This manner of constructing hoods is unfair and dangerous to the workman and unfair to the firm for whom the plant is being installed, for the reason that on the first visit of the factory inspector these hoods are ordered replaced by those of a more efficient construction. This entails a far greater expense than would have been incurred had the proper hoods been installed in the beginning. This department is ordering all hoods of an improper construction replaced by those that have the branch pipe connected to the hood directly beneath the part of the wheel that comes in contact with the work, and as near to the point of work on the wheel as the character of the work will permit. The department also advises and urges that an additional suction be provided in the rear of the wheel near the center, in order that the light floating dust that missed the front suction may be picked up and carried away. Where such an additional suction is used, care must be taken to design the two openings so that their combined area equals the area of the branch pipes into which they open. This light floating dust constitutes the dangerous element."

It is also stated that hoods must be of a substantial character so as to act as efficient guards for the wheels. Many accidents happen to workmen by pieces of work catching in the wheels and revolving with them. This often happens on buffing wheels, where employees' hands are sometimes badly mangled.

Another point in the construction of exhaust systems is to eliminate as many bends and elbows as possible. The dust collector should be installed as near the fan as possible, and the fan as near the wheel as possible. All branch pipes on blower systems where over three machines are connected should be equipped with blast gates for the purpose of equalizing the suction power, so that the pipes farthest away from the fan will get the required suction.

"A great fault," declares the report, "of several of the constructors of exhaust systems is an attempt by them to convince the manufacturer that the 5-in. suction power in the U-shaped tube, as required by the Illinois law, is not necessary. The department knows from practical experience that it is necessary and will insist upon that part of the law being complied with. The 5-in. suction is necessary so that the blast will extend far enough from the opening of the branch pipe to entirely cover the zone of the wheel, thereby removing the floating dust."

METHODS OF TESTING EXHAUST SYSTEMS.

Three methods of testing exhaust systems are contained in the report. The apparatus necessary for such a test is very simple, consisting only of a U-shaped tube and short pieces of rubber and metal tubing. The rubber tubing allows for the proper placing of the U tube, because in all testing the U tube must be exactly perpendicular. The short length of metal tubing attached to the end of the rubber pipe provides for perfectly stable conditions as regards the placing of the apparatus for a test which will record the nearest possible status to actual working conditions.

The first method is to tap the branch pipe with a center punch and insert the end of the pipe leading to the U-shaped tube. Care must be taken to punch the hole at least 6 in. from any elbow. This method is liable to error, because as a rule the air velocity recorded is that velocity near the edge of the pipe, which is less than the velocity near the center due to friction of the air blast with the sides of the pipe.

The second method is to insert a stationery tube, centrally located as regards the branch pipe to be tested, about 8 to 10 in. in the opening of the pipe.

The third method, which should only be used on systems of three or more machines, is to remove the hood and after making a small hole about one-eighth of an inch in diameter in the cardboard, to place the cardboard over the opening of the branch pipe and make the test at the hole in the card. Care must be taken to have the small test hole as near the center as possible, and to have all other branch pipes open at the time of the test. Of the three methods, the second one should be used, according to the department, whenever possible, as it is the most accurate, because it comes nearest to representing the actual conditions and requirements of practical work, and is least liable to error.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Arrangements for Semi-Annual Meeting.

Headquarters for the forthcoming meeting of the American Society of Heating and Ventilating Engineers, which will be held in Atlantic City, Thursday and Friday, September 16 and 17, will be at the Marlborough-Blenheim Hotel. The first session is called for Thursday afternoon. A second session will be held the same evening. The third and last session will be held Friday afternoon. This leaves both mornings free.

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According to a circular sent out by Secretary J. J. Blackmore, the American Society of Heating and Ventilating Engineers, at its next annual meeting, will devote one day to the subject of the cost of operating heating and ventilating plants. To assist the various committees that will collect the data, a set of questions has been prepared and sent out to the membership for the purpose of obtaining all the knowledge and experience possible relating to the subject. Data on two or more buildings are desired, if possible, and the cost of operation should extend over two seasons, to see how much variation there is in such costs. The investigation will cover schools, hospitals, public buildings, churches, office buildings, apartment buildings, stores, theatres, factories and residences. Committees to be appointed later will classify and correlate these data.

NATIONAL DISTRICT HEATING ASSOCIATION

Plans for Future Development.

The registration at the recent convention of the National District Heating Association reached high water mark, there being 260 in attendance, representing 72 district heating plants. These figures are given in a circular letter sent out by President David S. Boyden, who states that plans for making the association of still greater value and benefit are under way, including the following:

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To enlarge the scope of the work of the association in order to make it of the greatest value to the members and encourage the construction of district heating systems.

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Heat Emission from Radiators.

Editor HEATING AND VENTILATING MAGAZINE:

The articles on "Heat Emission from Radiators," which have appeared in your March and August issues, have prompted the writer to submit a table which he has used successfully for a number of years, and which varies from the one given by C. D. Allan.

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The following table is based on observations made of actual operating conditions in temperatures to 10° F. below zero, and altitudes up to 5,000 ft. It is assumed that the air moves over the heating surfaces at a speed of 3 ft. per second for heights above 20 in. and that the velocity diminishes as the height of the radiator is lessened.

TABLE OF HEAT EMISSION IN B.T.U. PER SQUARE FOOT OF CAST IRON RADIATION AT 150° F. DIFFERENCE BETWEEN STEAM AND AIR. SEA LEVEL CONDITIONS; RADIATOR LOCATED UNDER WINDOW.

Type of radiator.	Height of radiators in inches							
	38	32	26	22	20	18	16	14
One-column	285	290	295	300	298	295	292	290
Two-column	270	275	280	290	287	285	282	280
Three-column	250	255	260	270	268	266	263	260
Four-column	230	235	240	250	248	245	242	240
Flue, narrow.....	260	270	280	285	...	...	...	...
Flue, window.....	...	...	...	...	290	287	285	283
Wall, bars vertical.....	...	310	...	...	...	...	...	...
Wall, bars horizontal....	...	...	...	...	...	...	...	300
Wall, flat at floor.....	(as in dry room)				420	...	...	...
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The above is based on 70° F. inside, zero outside, at sea level. Wind velocity, 15 miles per hour, average for year.

Add 2% for every 500 ft. in altitude.

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Newark, N. J., August, 1915.

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A circular describing the methods of calibrating and using bomb calorimeters, for determining the amount of heat available in a given weight of coal, coke or other fuel, has recently been issued by the United States Bureau of Standards. As the available heat in any one kind of fuel depends largely upon its quality, it has become the practice, where fuel is purchased in large quantities, to determine the heat available per pound and from that determine the price of the fuel, usually described as purchase on "the B.T.U. basis."

The bomb calorimeter consists essentially of a steel shell in which a small, weighted sample of the fuel can be burned in pure oxygen gas. The bomb is immersed in a known amount of water before the sample is ignited. The heat produced warms the water and the difference in temperature of the heated water determines the amount of heat given off by the fuel.

In order to standardize the bomb calorimeter, use is made of standard samples of certain pure materials, such as sugar, naphthalene and benzoic acid. By burning known amounts of these substances in the bomb, the observer may determine the amount of heat required to raise the temperature of the bomb, together with the proper amount of water, one degree. This being determined, the amount of heat fur-

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nished by a given sample of coal burned in the same bomb, with the same amount of water, is readily found. By the use of these samples, which are furnished by the Bureau of Standards, it is possible to obtain correct results from tests made anywhere.

Panama-Pacific International Exposition.

5—KEUFFEL & ESSER COMPANY.

Three Grand Prizes have been awarded to the Keuffel & Esser Co., Hoboken, N. J., at the Panama-Pacific International Exposition, for their exhibits of drawing materials and slide rules, surveying instruments and telescopic sights and periscopes. Unusual interest centers in the exhibit of this company as it furnished many of the engineering instruments used in the construction of the Panama Canal.

The exhibit comprises practically every requirement of the engineer for field or office work. The variety of devices ranges from the small hand instruments used for the roughest preliminary survey to a triangulation theodolite, reading angles to single seconds, and a photo-theodolite, representing the finest types of precision instrument construction. Among the improved and time and labor-saving devices shown are the K. & E. stadia circle, a device simplifying to the last degree the reduction of stadia measurements and obviating the necessity of using the charts, tables and slide rules now familiar to the engineer.

The slide rules shown include many new types. The chemist's duplex slide rule is especially adapted to the solution of problems in stoichiometry, such as gravimetric and volumetric analysis, equivalents, percentage composition, conversion factors and many other problems familiar to the chemist.

The Allen friction head slide rule simplifies the calculations connected with the installation of steam heating, hot water heating and steam power piping.

The surveyor's slide rule reduces the calculation of azimuth meridian and stadia reductions and other hitherto complicated calculations to mere mechanical operations and enables the engineer in the field to compile these data using the ordinary engineer's transit fitted with vertical circle.

The Roylance electrical slide rule gives a single setting for any standard size copper wire, the diameter in mils, area in circular mils, area in square inches, weight in pounds per 1,000 ft. of bare wire, resistance in ohms per 1,000 ft. at any degree centigrade and the carrying capacity of different kinds of wires and cables.

The K. & E. power computing slide rule solves the equation, Plan/33,000 equals H.P., and computes the power and dimensions of steam, gas and oil engines.

The merchant's slide rule is especially designed to meet the needs of the merchant and solves in a simple manner such calculations as discounts, simple and compound interest, prorating, converting feet into meters, pounds into kilograms, taking off a series of discounts, adding profits to cost, etc. In fact, almost all problems which are of everyday occurrence in the office or workshop can be solved without mental strain and at a remarkable saving in time.

A complete line of drafting room furniture, such as tables, chests, blueprinting frames and machines, drawing boards and drawing tools is attractively displayed.

To complete the exhibit, a testing laboratory has been installed wherein are demonstrated all of those tests which are

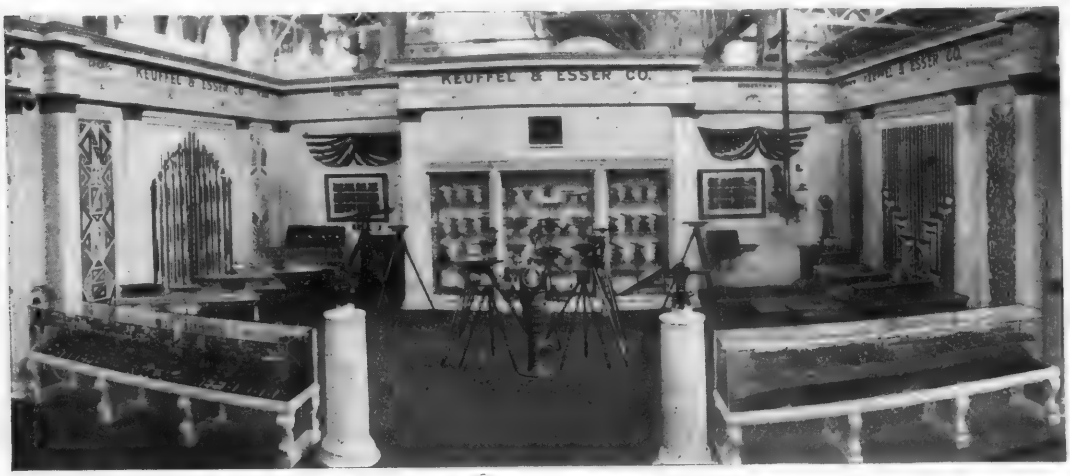


EXHIBIT OF KEUFFEL & ESSER AT THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION.

EXHIBIT OF THE UNITED ELECTRIC COMPANY AT PANAMA-PACIFIC INTERNATIONAL EXPOSITION.

necessary to insure the quality and accuracy of all K. & E. products.

6—THE UNITED ELECTRIC COMPANY.

The entire line of Tuec stationary cleaners, manufactured by the United Electric Company, Canton, O., are shown in the exhibit of this company at the Panama-Pacific International Exposition. Four machines are set up on the floor, all connected and illustrating the various methods of installation. Every tool manufactured by the company is also included in the display, as well as every kind of hose. In addition to the regular sections of hose, 6-in. lengths of each are on exhibition showing the cross sections.

A complete line of the different inlet valves, in all finishes, are shown, together with a full set of inlet shanks in the different lengths. These shanks are coppered, and nickeled, but not polished, and present a most unusual appearance. All of the 2½-in. fittings are arranged in that part of the booth where the inlets and tools are shown.

A rotor, fan, etc., is placed in a prominent place where they can be examined easily, and a case, lined with green felt, contains four different size S. K. F. bearings. This, in itself, attracts considerable attention, as it brings out the quality of the only two wearing surfaces in the Tuec. The rail around the booth is a novelty and is made up of Tuec pipe and fittings, bearing out the color scheme in vogue through out the booth.

The exhibit is located in the Varied Industries Building, and is in charge of Jerry Snyder, manager of the company's Toronto factory.

NEW DEVICES

New Gas-Steam Radiator.

Something new in the way of a gas-steam radiator has recently been brought out by the Garwood Gas Lamp & Heater Co., Canton, O., and is shown herewith. This apparatus, it is stated, is the result of more than eight years of exhaustive experimenting. The radiator, it will be noticed, is a heating unit in itself, having no water connection. Four or five quarts of water are poured in the water-filling plug once every four or five months.

The radiator consists of a series of plain design radiator sections, an automatic thermostatic valve and a gas burner. It is claimed that this is the first heating appliance of its kind which will not permit the products of combustion to escape to the room heated. This is due to the new unitary heating and combustion chamber

which consists of a series of ribs on the middle sections of the radiator which dovetail together when the sections are assembled. This construction affords a completely enclosed combustion chamber, there being no openings except the small air ports at the bottom which provide for the secondary air supply for the flame.

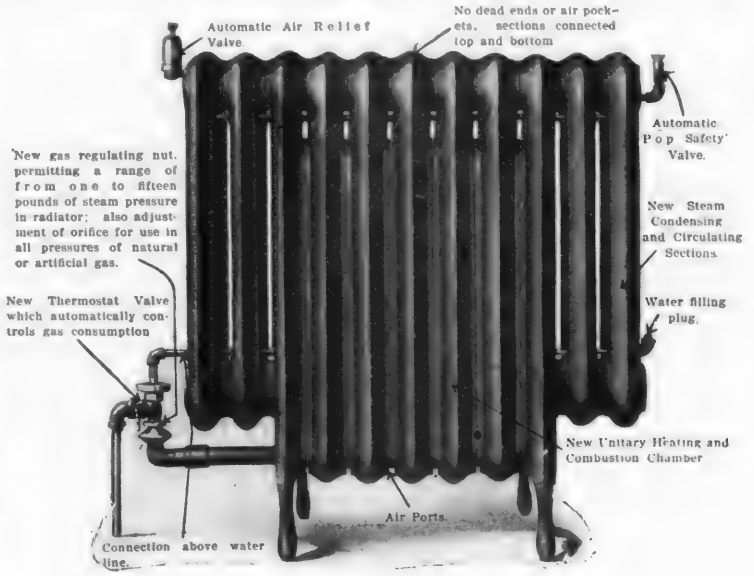
A new circulating method is obtained by the use of overhanging loops which are placed at each end of the radiator. These loops do not come over the gas burner, so that a different temperature exists in the overhanging loops than in the center loops which are directly over the burner. As all sections are connected at the top, this arrangement provides that the steam as generated will rise and flow into the overhanging loops where it condenses and runs down to the bottom of these loops. The water then finds its level back over the heat of the burner.

In a test of a 10-section radiator which is reported by the manufacturers, using 4 qts. of water and plugging the return opening from the overhanging loops, less than 5 hrs. were required before all of the water was in the four overhanging loops. At the end of these 5 hrs. the six middle loops were dry.

Although the new gas regulating nut in the radiator permits a range of from 1 to 15 lbs. of steam pressure in the radiator, this nut is set to 5 lbs. pressure. As soon as the gas is lighted, steam begins to be generated in the radiator. As the steam pressure increases, the gas consumption decreases, and, after 5 lbs. pressure has been reached, only enough gas is consumed to maintain these 5 lbs. of steam pressure.

This radiator is made in two distinctive styles. In addition to the type described, another style is made without the combustion chamber. This type is for use especially in sections of the country where artificial gas is burned. The object of the heating and combustion chamber, with flue connection, is to carry away all fumes and condensation, but with artificial gas, it is stated, this is usually unnecessary.

In regard to gas consumption, a test was made on one radiator of eleven 26-in. sections, 3-column, containing about 42 sq. ft. of radiation. This radiator required 18 cu. ft. of gas per hour to raise 5 lbs. of steam pressure with 3 qts. of water, this being accomplished in 17 min. After this steam pressure was reached, the thermostatic valve automatically cut down the gas consumption to less than 8 cu. ft. per hour, at which point the 5 lbs. of steam pressure was maintained in the radiator for 72 hrs.


Automatic Air Relief Valve.
No dead ends or air pockets, sections connected top and bottom
Automatic Pop Safety Valve.
New gas regulating nut, permitting a range of from one to fifteen pounds of steam pressure in radiator; also adjustment of orifice for use in all pressures of natural or artificial gas.
New Steam Condensing and Circulating Sections.
New Thermostat Valve which automatically controls gas consumption
Water filling plug.
New Unitary Heating and Combustion Chamber
Air Ports.
Connection above water line.

NEW TYPE OF GAS STEAM RADIATOR.

Trade Literature.

SAVO AIR MOISTENER, intended for use on any steam or hot water radiator to supply any desired amount of moisture in a room, is an interesting product of the Savo Mfg. Co., Chicago, Ill. The device is described and illustrated in a circular recently issued by this company. One of the features of the Savo air moistener is its compactness which permits it to be placed at the back of the radiator out of sight. It is made in three styles, Style No. 1 being 14 in. high and 12½ in. wide; Style No. 2 is 14 in. high and 8 in. wide; Style No. 3, 9 in. high and 12½ in. wide, and Style No. 4, 9 in. high and 5 in. wide. Still another style is made for use in connection with warm air furnaces, supplanting the water pan in the furnace. This style, No. 5, is adjusted to fit in any floor register box where the diameter of the hot air pipe is from 8 to 12 in. The company's standard size moistenners are made to fit radiators which measure 2½ in. from the outside of one coil to the outside point of the next coil, but the company makes Nos. 1 and 3 styles to fit radi-

ators of different construction. Emphasis is properly laid on the point that one moistener should not be expected to humidify an entire house. A number of facsimile letters are included expressing the satisfaction of users in residences, offices, piano warerooms, schools and hospitals. Numerous authorities are

SAVO AIR MOISTENER.

quoted on the disastrous effects of dry indoor air and the advantages of proper indoor humidity.

CLEVELAND AUTOMATIC CONDENSATION PUMP AND RECEIVER is the subject of a timely circular describing this apparatus which serves to return the condensation from a heating system to the boiler automatically. The motor

FILLING SAVO AIR MOISTENER WITH WATER.

and automatic control are mounted on the receiver cover and when the receiver is placed below the floor level it requires little space. Ten points of superiority possessed by the Cleveland are given, as (1) automatic and dependable; (2) requires no unusual attention; (3) automatic oiling arrangement; (4) complete, compact, simple and efficient; (5) all steam jackets packed; (6) motor placed at highest point above water—impossible to flood or splash; (7) float may be removed without disturbing other parts; (8) weight and thrust of pump carried by ball thrust bearings, independent of motor; (9) pump and motor shafts connected through flexible coupling; (10) pump and switch rods provided with stuffing boxes. All sizes are designed for 15 lbs. boiler pressure. The apparatus is made by the Cleveland Pump & Supply Co., Cleveland, O., also manufacturers of automatic electric sump pumps, cellar drains and sewage ejectors.

CLEVELAND AUTOMATIC CONDENSATION PUMP AND RECEIVER.

POWELL BOILER VALVES, illustrating the complete line of boiler room valves, including the White Star valve, made by the Wm. Powell Company, Cincinnati, O., are the subject of a new booklet. From this line, it is stated, suitable valves may be selected for installation in any industrial plant in the country. The company adds that it is prepared at all times to furnish Monel metal valves at special prices. The general description given of the construction of the Powell line leaves no doubt of the quality of this product, as well as the care used in its manufacture. The valves especially featured in the catalogue include the Powell patent "Cyclone" blow-off valve, extra heavy iron body straightway "Y" blow-off valve, the new Powell "Irenew" valve, the Powell "White Star" boiler gate valves and "Model Star" gate valve, the new Powell "White Star"

double automatic boiler check valve and the Powell automatic injector. The company also makes a complete line of boiler and engine room trimmings.

HUGHSON STEAM SPECIALTIES, now sold by the Illinois Engineering Company, Chicago, Ill., succeeding the Hughson Steam Specialty Company, are called to the attention of the trade in a catalogue devoted to the Eclipse line. This line includes regulating, blow off, automatic stop and check valves and separators made of semi-steel, or of steel and with bronze, nickel bronze, Monel metal or nickel steel trimmings. This line was formerly made by the John Davis Company. Size 6 x 9 in. Pp. 40.

DETROIT'S INDUSTRIAL PLANTS are shown on a post card folder, containing 22 views, 12 of which are those of the world's largest manufacturers in their respective lines. One of those shown is the plant of the American Blower Company.

Winner Boiler Compound.

Winner boiler compound, described as an eradicator and sure preventive of scale formation in boilers, is an interesting product of The Winner Co., 71 Morton Street, New York. This compound is equally adaptable to marine and stationary boilers and excellent results are reported in a number of Coast line vessels in which the compound is regularly used. The manufacturers emphasize the point that Winner boiler compound contains no element that will damage piston rings or packing, and that it is effective in removing and preventing scale from magnesia, iron, sulphur, sulphate of lime, carbonate of lime, phosphate of lime or any mineral matter held in solution. The company gives interesting figures regarding the increase of fuel necessary to produce a certain steam pressure through a coating of scale. For 1/16 in. of scale, the fuel increase is given as 10 per cent.; for ¼ in. scale, the fuel increase is 40 per cent. One gallon of the Winner compound is recommended to 1,000 H.P. every 24 hours as sufficient to produce satisfactory results. The company is represented in New York by Joseph H. Sloan.

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TRADE AND MISCELLANEOUS NOTES

Coming Events.

September 16 and 17, 1915.—Midsummer meeting of the American Society of Heating and Ventilating Engineers at Atlantic City, N. J. Headquarters at the Marlborough-Blenheim Hotel. Secretary, J. J. Blackmore, 29 West 39th Street, New York.

Miscellaneous Notes.

Springfield, Mass.—A loan of $10,000 has been recommended by the city's finance committee for the construction of a central heating plant in connection with the new isolation hospital.

Mount Vernon, Ia.—Difficulty in determining the location of the proposed central heating plant for the college buildings at that point has delayed the beginning of construction work.

Fargo, N. D.—The Oakes Public Service Company is the name under which the company which is to furnish steam heat to the business districts of Oakes will be known. Mains are being laid from the Oakes Light & Power Co.'s light plant to the four principal business blocks of the city. The franchise under which the company is working was granted last winter and necessitated the starting of work by October 1. Steam will be sold on a meter basis.

Portland, Ore.—Plans are practically completed for the new public auditorium to be built on the block at Third and Market Streets. The architects for this important building are Freedlander & Seymour, New York.

Sacramento, Cal.—Two hundred employees of the Pacific Gas & Electric Company have organized a "Pacific Service" Co-operative Club, for the mutual benefit of employees of the company. Meetings will be held at stipulated times for the exchange of ideas and suggestions as to improvement in "service and safety."

Chicago, Ill.—Statements made by Ralph C. Otis, trustee of the Chicago Board of Education, when a witness before the Baldwin Senate Educational Committee, inferring that political pressure had been brought to bear upon him and the buildings and grounds committee of the board for the adoption of the Berry window ventilator in the public schools, were challenged by Dr. Milton H. Berry, patentee of the ventilator, and by the Orr & Lockett Hardware Company, agents for the ventilator in Chicago. Mr. Berry stated that Mrs. Young, at that time superintendent of education, first brought the Berry ventilator to the attention of the school board and that the price at which the ventilator was offered to the board was 72 cents per lineal foot, instead of $1.50 or $2.50 a lineal foot, as, he said, was testified by Mr. Otis, and that the average price per window installed was $2.70. Mr. Berry further stated that "the fact that this ventilator has been before the board for nearly four years and now sleeps in a subcommittee shows what effect this so-called political pressure has resulted in. When a reputable concern such as the Orr & Lockett Hardware Company presents a device such as the Berry window ventilator at an expenditure of $1,000, equips two schools at the request of the board free of charge and represents to the

Genuine Armstrong Stocks and Dies

MALLEABLE HINGED PIPE VISES

PIPE CUTTERS

PIPE MACHINES, HAND OR POWER

The Tools of Constant Service

Manufactured by Write for Catalog

THE ARMSTRONG MFG. CO., 321 Knowlton St., BRIDGEPORT, CONN.

board that it is the best thing of its kind it has found on the market and backs it up with a five-year guarantee, then the school board should give it business attention. I may be yet inspired to write a history, entitled 'Why Fresh Air Has Been Denied the School Children of Chicago'."

Mr. Lockett, in his letter to the Senate committee, after referring to the insinuation as brought out in the testimony, that the Orr & Lockett Hardware Company was making a deliberate effort to steal from $50,000 to $60,000 from the board of education stated that "the records show that the Berry window ventilator was first recommended for portable schools by Superintendent Young and rejected because the architect and engineer stated that their method of injecting air through a furnace proved adequate. Later Superintendent Young again recommended these ventilators for the portables, stating that the necessary ventilation by other means was not forthcoming. An order was placed for ventilators to be installed in portables. A certain number of portables and rented schools were to be equipped with the Berry window ventilator and a certain number of portables and rented schools were to be equipped with another make of ventilator and still more portables and rented schools were to be equipped with a ventilator made by the repair department, and a subcommittee was to investigate and choose the best ventilator. To the best of our knowledge no ventilator but the Berry was installed on any of these portables, so that there was no way of making a comparison.

"The writer personally went before the building and grounds committee, of which Mr. Otis was chairman, and agreed to equip at our own expense any two schools that they might select for tests. So far as we can learn, no investigation has ever been made; although a committee was appointed for this work, it has never reported."

Rock Island, Ill.—The heating of the Court House in Rock Island during at least the early part of the coming winter has become a pressing problem on account of the delay in the construction of the new $75,000 jail and heating plant. A suggestion has been made that temporary heat be procured from St. Joseph's Church, located across the street. Members of St. Joseph's Church, however, have made strenuous objection to the location of the new county jail on the Court House square in front of St. Joseph's school, and an injunction suit has been filed by Bishop Dunne against the county board.

Reading, Pa.—The Reading Steam Heat & Power Co., Reading, Pa., is installing

There's a little valve that is reliable!

IT'S a VacUstat, and is reliable in more ways than one—first of all it is reliable in the sense that you can depend on it to work right and perform its functions properly **always**; and again it is reliable because it is one of the RELIABLE Vacuum Heating Specialties.

VACUSTAT

TRADE MARK REG. U.S. PAT. OFF.

The VacUstat is a thermostatic valve, which automatically keeps the radiators, piping and boiler free from air, prevents escape of steam and insures quick, thorough and even heat circulation, by making every radiator fully efficient. The VacUstat has larger venting capacity, is entirely different and far superior to any other air valve. VacUstats are part of the RELIABLE Air Line Vacuum Heating Equipment, which is used to perfect steam heating plants and to save fuel. Being properly and permanently adjusted at our factory, VacUstats can be installed quickly and at unusually low cost, and after installing VacUstats it is not necessary to go back to the job to make other adjustments.

Install VacUstats—insist on using them—and both you and your customer will be perfectly satisfied with the results.

RELIABLE Heating Specialties—Electric and Hydraulic Vacuum Pumps, VacUstats, Vacu-Traps, Vacu-Graduate Packless Valves, "4-V" Valves, Vacu-Checks, etc.—are Standardized and Staple, and carried in stock by most representative jobbers.

The RELIABLE Heating Equipment catalog will interest you—write for a copy today! Ask for Booklet "K"

THE BISHOP-BABCOCK-BECKER CO.

General Offices, CLEVELAND, OHIO

New York Chicago Milwaukee Cincinnati St. Paul St. Louis San Francisco

meters in all of the buildings which it serves with steam heat. Over 300 meters will be placed in service before the opening of the heating season.

Fond du Lac, Wis.—The board of directors of the Y. M. C. A. in Fond du Lac has voted to install a new heating plant in the Association building and has appointed a committee to investigate the matter.

Worthington, Minn.—Worthington is to have a central heating plant to heat the business district of the city. Exhaust steam will be used from the electric light and pumping station and carried through underground steam mains to the buildings to be heated. The company has been capitalized at $30,000 and will start operations with the opening of the heating season in the fall.

Charlottenburg, Germany.—A new section of the Technical High School has been opened for the purpose of conducting tests on heating and ventilating apparatus. Contributions to the amount of 120,000 marks have been made by the various industries interested. The testing room is 200 ft. in length and there is also a boiler and machinery room, where extensive installations may be made.

Milwaukee, Wis.—The Milwaukee Plumbing & Heating Supply Co. suffered the loss of its stock in a fire which destroyed its building at 136 West Water Street, July 5.

Malden, Mass.—A plan for the construction of a central heating plant to supply the City Hall, high school and another school, which has been under consideration, has been abandoned. The city solicitor ruled that the streets could not be opened for the laying of underground conduits without legislative permission, especially as the buildings are situated some distance from each other. A new boiler has therefore been installed at the City Hall.

W. G. Cornell Co., New York, heating and plumbing engineers and contractors, held a successful outing for its employees, July 24, at Hoffmann's Park, Westchester. After a day devoted to athletic events, dinner was served, with H. G. Issertell acting as toastmaster. The company's entire force was present, led by President W. G. Cornell.

Hartford, Conn.—A central heating plant to take care of three State buildings at Hartford, including the Capitol, State Library Building and the armory, is under consideration. State Comptroller Webster has the project in charge.

Stockbridge, Mass.—A central heating plant to supply the local telephone exchange and two adjoining buildings is being installed by Frank V. Anderson, of that place.

Building Operations for July made a more favorable showing than for several months previous. Although the total net loss was 16%, in many of the larger cities the comparative loss was small. In New York, for instance, the figures were $13,756,526, as compared with $13,927,743 for July, 1914. Cities reporting increases included Buffalo, 52%; Cincinnati, 21%; Des Moines, 29%; Kansas City, 41%; Louisville, 13%; Minneapolis, 11%; Oklahoma, 29%; Omaha, 38%, and Washington, 19%. The most notable losses were reported from Chicago, 28%; Detroit, 15%; Indianapolis, 47%; Newark,

Jenkins Bros. Fractional Radiator Valves

For use in connection with Atmospheric, Vapor, and Vacuum Return Line Systems.

Open wide in five-sixths of a turn. Opening is correctly graduated and partial heating of the radiator is easily controlled. The large and plainly marked indicator plate is adjustable and marking can be set to any point in the circle. The Jenkins Bros. Disc. standard of design, metal and workmanship, is an assurance of quality and satisfaction.

Write for catalogue No. 20.

JENKINS BROS., New York, Boston, Philadelphia, Chicago, Montreal, London

SPECIFY FOXBORO THERMOMETERS
TRADE MARK
SEE OUR EXHIBIT—PANAMA PACIFIC EXPOSITION
San Francisco, Cal., Palace of Machinery, Corner 3rd St. and Avenue C2
THE FOXBORO COMPANY Succeeding The Industrial Instrument Co.
New York Chicago FOXBORO, MASS., U. S. A. San Francisco St. Louis

50%; Philadelphia, 21%; Pittsburgh, 21%; San Francisco, 27%; St. Louis, 52%; Seattle, 87%, and St. Paul, 27%.

Springfield, Minn.—A petition has been started in Springfield for a municipal heating plant in connection with the electric light plant of that city. The petition provides that the city shall install such a plant to cover the business section adjacent to the power plant. The business men of the town are attempting to raise $7,000 by subscription towards the cost of the plant, this amount to be placed to their credit and applied to their heat bills when the plant is in operation.

Manufacturers' Notes.

Illinois Engineering Co., Chicago, Ill., announces that it has purchased the plant and business of the Hughson Steam Specialty Co., manufacturers of the John Davis Co. Eclipse line of steam specialties. H. H. Hughson, formerly president of the Hughson Steam Specialty Co., will continue with the business as manager of the Illinois Engineering Company's steam specialty department. The company states that the high quality of these goods will be maintained in every respect.

Sims Co., Erie, Pa., reports a successful ending of the first year of its New York office, handling the Sims feed water heaters of the open and closed types, as well as hot water heaters of the instantaneous generator and combined storage types. Recent orders placed with the New York office include heaters for the Chestnut Street School, Montclair, N. J.; Mohawk Hotel, Schenectady, N. Y.; City & Suburban Homes Co., Bowery Y. M. C. A., Frick Hotel Annex, New York; Long Island State Hospital, Brooklyn; and New York State School of Agriculture at Farmingdale, L. I. Two of the four heaters for the latter institution are 8 ft. in diameter by 15 ft. high, each containing 664 2-in. tubes. The company's New York manager is P. A. Moulton, with headquarters in the Marbridge Building, Broadway and 34th Street.

Hart & Crouse Co., Utica, N. Y., reports the shipment of a 75-h.p. smokeless cast-iron sectional down-draft boiler, to replace an old boiler installation in the White House at Washington, D. C.

American Radiator Co., Chicago, Ill., has completed its new plant at Bayonne, N. J., and as soon as business warrants, the plant will be operated to supply the export trade in countries where the company has no works. The company has declared a dividend of 1¾% on its preferred stock, payable August 16, also a dividend of 4% on the common stock, payable September 30.

There is a Great Difference

these hot days—between the man-power of an employe in a Carrier Equipped factory and the man-power of an employe in a factory that knows nothing of this system.

Carrier Humidifiers

will cool the air to the outside wet bulb temperature—or an average cooling of about 15° F.

Why not investigate now—and show your clients that efficiency—in the summer time—can easily be increased by installing **Carrier Apparatus?**

Send for Catalog 13-36.

CARRIER AIR CONDITIONING CO. OF AMERICA

Buffalo, N. Y.

Boston **Philadelphia**
New York **Chicago**

Webster Air Conditioning Apparatus

Webster Air-Conditioning apparatus is constantly demonstrating its capacity, under a wide variety of exacting conditions, to effect and maintain any desired temperature and humidity.

Wherever a highly efficient and thoroughly dependable air-cooling or air-conditioning system is required, Webster apparatus, by reason of exclusive advantages, merits unquestioned consideration.

Widely installed in hotels, restaurants, office and administration buildings, as well as industrial establishments where special air-cooling and air-conditioning problems are to be met.

Our catalogues and engineering force are at your command.
We guarantee results.

WARREN WEBSTER & CO.

ESTABLISHED 1888 — **CAMDEN, N. J.** — BRANCHES IN PRINCIPAL CITIES

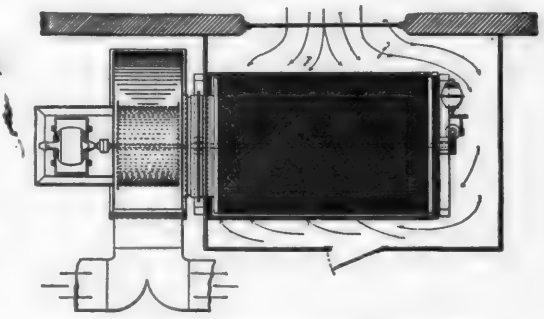
Kingwelton Talks No. 8.

Successful Operation Tells the Story

A few of the many places where

Kingwelton Rotary Air Washers

May be seen:



(Patented August 13, 1912) Plan View

Washington, D. C.
The Union R. R. Station

Pittsburgh
The Union R. R. Station

Chicago
People's Gas Co. Building

New York
Singer Mfg. Co.'s Building
Flatiron Restaurant
Residence of Mr. O. G. Jennings
American Mfg. Co.
National Park Bank
Breslin Hotel

Toronto, Canada
Independent Order of Foresters

The Kingwelton operates at 1/10 of the cost of other air washers while performing the same service. One revolution per minutes requires but 1 H. P. per 50,000 cu. ft. of air supplied per minute. Other volumes in proportion. Made to fit any reasonable location and to purify any desired volume of air.

Write for descriptive circular

WELLS & NEWTON CO., Ave. B and 17th St., NEW YORK

The year's business has been about equal to that of 1914 for the same period.

National Tube Co., Pittsburgh, Pa., it is announced, will shortly build a new $5,000,000 mill adjoining the company's present plant at Wheeling, W. Va.

International Steam Pump Co., New York, has closed a contract for the manufacture of shells and other munitions, amounting to between $5,000,000 and $10,000,000.

Wm. H. Page Boiler Co. announces the removal of its Philadelphia offices from 620 Arch Street to 117 North 16th Street. A display of the company's line of boilers and radiators is shown in the new quarters. C. L. Roach is the company's Philadelphia manager.

Boston Stock & Die Co., Boston, Mass., is the changed name of the Harrington Mfg. Co., 36 Whittier Street, Boston. The company's officers are: President, J. J. Haggerty; treasurer, F. W. Rugg; secretary, J. P. Murphy; general manager, C. E. Gill.

Central Foundry Co., New York, announces the election of C. C. Todd as vice-president of the company. Mr. Todd was formerly manager of the company's Chicago branch. Hereafter he will make his headquarters in New York.

New Incorporations.

Pontiac Plumbing & Supply Co., Pontiac, Mich., capital $2,000, organized to conduct a heating and plumbing business.

Rector Gas Heating Co., Kansas City, Mo., capital $100,000. Incorporators: George H. Opdyke, O. M. Edmonsen and Paul W. Bradley.

Hammond Heating Co., Cincinnati, O., capital $10,000. Incorporators: L. W. Hammond, H. M. Dalton and L. M. Hammond.

Johnson Kitchen Ventilator Co., Philadelphia, Pa., capital $200,000, to manufacture kitchen ventilators and to deal in stoves and furnaces. Incorporators: Allen S. Johnson, Frank P. Morgan and Holmes Conrad, Jr., all of Washington, D. C.

Detroit Improved Blackwall Co., Detroit, Mich., capital $100,000, to deal in heating appliances. Incorporators: George G. Brown, William O'Doughahey and Albert T. Lambert.

Kelly Plumbing & Heating Co., Newark, N. J., capital $125,000, to conduct a contracting business in heating and sanitary engineering work. Incorporators: James

CARRIER
Engineering Corporation
39 CORTLANDT STREET - NEW YORK

Specialist in Air Conditioning and Drying.

The Organization That Developed Air Conditioning.

Write us if your problem concerns humidifying, dehumidifying or the automatic control of either.

F. Kelly, Orange; Charles N. Fay, Newark; and William Englert, East Orange.

Ventilation Corporation, Wilmington, Del., capital $125,000, to manufacture ventilating apparatus of all kinds. Incorporators: W. J. Maloney, Wilmington, Del., and others.

Springfield Plumbing & Heating Co., Springfield, Mass., capital $30,000. Incorporators: Max Radding, Julius Radding and Abraham H. Slavin.

Adelman & Ehrlich Co., Chicago, incorporated to manufacture and deal in heating appliances and accessories. Incorporators: Charles G. Adelman, Charles H. Ehrlich and Lewis F. Jacobson.

Patterson, Gottfried & Hunter, Inc., New York, has been incorporated to succeed the firm of the same name which has been in bankruptcy since October, 1913. The company will occupy the same quarters at 147-151 Lafayette Street as a supply house for heating and plumbing supplies. The new corporation has acquired all the assets of the old concern except the trustee's accounts receivable and cash due the trustee on March 31 last, and assumes liability for the operating expenses and merchandise delivered on or after April 1, the same including goods previously ordered by the trustee but undelivered on that date. The purchase of the assets was made by a syndicate of former stockholders and accepted by the court after creditors representing 95% of all filed claims had declared themselves in favor of its acceptance. Albert M. Maretzek, who was prominently identified with the old concern and under whose management as trustee the business was conducted during bankruptcy, will continue with the company as manager.

Cadillac Plumbing & Heating Co., Cadillac, Mich., capital $9,000, to take over the business conducted under the same name.

Hammond Heating Co., Cincinnati, O., capital $10,000, to conduct a heating and ventilating engineering and contracting business. Incorporators: L. W. Hammond, L. M. Hammond, H. M. Dalton and E. A. Winter. L. W. Hammond is president and treasurer of the Peck-Hammond Co., of Cincinnati.

W. A. Bywater Plumbing Co., Salt Lake City, Utah, capital $50,000. President, W. A. Bywater; secretary and treasurer, E. Bywater.

Augenstein Plumbing & Supply Co., Newark, N. J., capital $50,000, to conduct a heating and plumbing business.

If you want a good return on your heat insulation investment, give J-M Insulation Service the job

A steam plant must be at the highest possible efficiency. That's why you are so careful to keep your boiler evaporation as high as you can. For the same reason you must watch the coal pile, do careful firing and keep your condenser vacuum at the low point. But what about the heat that is silently leaking all along the line? Is your pipe covering an insulation? It should be—if your plant is to be efficient.

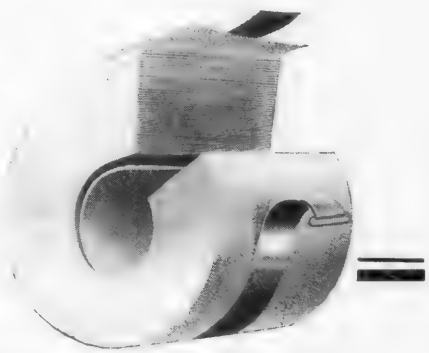
There is a J-M Insulation for every condition. Skilled specialists are ready to confer with you about them and a corps of men near you to apply the proper insulation, properly. Let us in on the very next job you have.

Write for Catalog No. 100

JOHNS-MANVILLE SERVICE COVERS THE CONTINENT

H. W. JOHNS-MANVILLE CO.

New York and every large city 3141D



Please mention THE HEATING AND VENTILATING MAGAZINE *when you write.*

Holmes-Landwehe Heating Co., Toledo, O., capital $10,000. Incorporators: Joseph Holmes, Ida Holmes, Herman Landwehe, Helen Landwehe and Burthlew F. Lyon.

Efficiency Distributors, Inc., New York, capital $30,000, to manufacture and deal in steam radiators and fireless cookers. Incorporators: R. Shoemaker, M. E. Baird and E. H. Eilson.

New Firms and Business Changes.

Central Plumbing & Heating Co., Springfield, Mo., is the title of a new firm which has opened quarters at 703 North Jefferson Street. G. Ferguson is at the head of the business.

Bullis & Hanson, Hastings, Minn., is a new co-partnership in the heating and plumbing business, composed of C. H. Bullis and R. C. Hanson. The company has opened an office at Sixth and Eddy Streets.

Meneley-Ross Co., Champaign, Ill., is the new title of the heating and plumbing firm of E. A. Robinson Co., which was established in Champaign forty-five years ago. Mr. Robinson, the founder of the business, will retire after a long and active career. The principals of the Meneley-Ross Co. are C. W. Meneley, formerly sanitary and heating engineer for the N. O. Nelson Mfg. Co., of St. Louis, and Roy M. Ross, who for the past two years, since his graduation from the University of Illinois, has been in the Comptroller's office at the university.

Contracts Awarded.

(Where bids for heating and ventilating equipment do not exceed $2,000, the work is usually well under way by the time the item is published in this column. Such items are only intended to give our readers a line on the activities of the trade.)

Bernard Gause, Jacksonville, Ill., heating and ventilating Franklin School at Jacksonville, for $1,825. Other bids were: C. C. Schureman, $1,558; and E. E. Beastall, $1,712.50.

A. S. Thompson, Madison, Wis., heating and ventilating West Side School in Madison, for $2,300.

David Ahern & Sons, Fond du Lac, Wis., heating and ventilating Grant School in Fond du Lac for $2,090. Other bids were: Ahern-McCoy Co., $2,368; Sanitary Plumbing Co., $2,441; W. A. Bowers Heating Co., $2,578; and Thomas Lapine, $2,970.

Kutzke & Senger, Portage, Wis., steam heating, Murrills & Taylor Building.

Brownell Co., Dayton, O., installing two new boilers at the heating and lighting plant of the Court House at Troy, O., for $6,460.

Eastman Plumbing Co., Albany, Ga., heating City Auditorium at Albany, for $4,207. The equipment included a No. 9 Sirocco fan, delivering 25,500 cu. ft. of air per minute, and 2,605 sq. ft. of direct radiation, in addition to 1,008 sq. ft. of Vento stacks.

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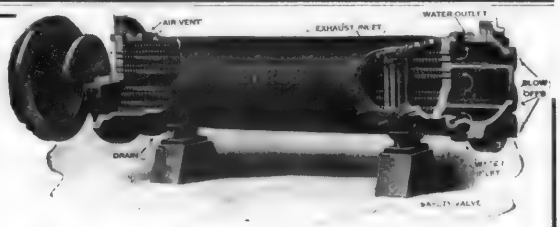

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Buck & Raynor Bldg., Chicago, 2 washers.
Deshler Hotel, Columbus, O., 3 washers, 1 special cooling washer.
Detroit Post Office, 1 washer.

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And All Principal Cities of the World

George Karl, Havana, Ill., heating and ventilating Riverview and Rockwell Schools at Peoria, for $3,370. Mr. Karl also received the contract for plumbing in the Riverview School, at his bid of $1,535. The plumbing contract for the Rockwell School went to J. F. Dare, at his bid of $1,535.

Sullivan Bros. Plumbing Co., Quincy, Ill., heating and ventilating County Home at Quincy, for $6,500.

Brabury-Martin & Sass, Lafayette, Ind., heating and plumbing new Eckhaus Block on State Street, Lafayette.

American Warming & Ventilating Co., Toledo, O., heating and ventilating East and West Branch Schools at Adrian, Mich., for $3,100 (for the East Branch) and $2,665 (for the West Branch).

M. B. Sanders, Little Rock, Ark., heating, ventilating and plumbing the U. M. Rose School in Little Rock, for $10,000.

McMahon Co., Kansas City, Mo., heating and ventilating the Normal School building at Maryville, Mo., for $11,800. Other bids were: Saline Plumbing Co., Saline, Kan., $13,747; Martin-Welch Hardware Co., Independence, Mo., $17,400; A. Holtman Heating Co., Kansas City, $12,991; B. Grunwald, Omaha, Neb., $12,450; Standard Plumbing Co., Maryville, $13,500; Urbauer-Atwood Heating Co., St. Louis, $13,400. The bid of the Urbauer-Atwood Co. was sent by registered mail but did not reach the board in time to be considered. The work was to be completed by September 20.

Egyptian Plumbing & Heating Co., Herrin, Ill., heating and plumbing new school in that city.

American Plumbing & Supply Co., Toledo, O., heating and ventilating Northern High School at Springfield, O., for $6,000.

Lamneck Co., Columbus, O., heating and ventilating high school at Dundee, O., for $2,150.

F. J. Hotop, Kalamazoo, Mich., heating and plumbing new armory building at Owosso, for $10,000.

Wichita Heating & Plumbing Co., Wichita, Kan., heating, ventilating and plumbing high school buildings in Neal, Bentley, Meade and Dexter, Kan.; also heating and ventilating Sherman School in Hutchinson, for $11,000; heating and plumbing National Bank Building in Pratt, for $4,000; and heating and plumbing Fourth National Bank of Wichita, for $17,000.

Hoagland-Lakin Electrical & Engineering Co., Los Angeles, Cal., heating and ventilating new high school at Lancaster, for $2,848.

H. J. Crawford, Los Angeles, heating and ventilating Budlong Avenue School in Los Angeles, for $3,393.

Winfield Heating & Plumbing Co., Winfield, Kan., heating and plumbing new dormitory of St. John's College, for $8,000.

Moore Plumbing & Heating Co., Wichita, Kan., heating and ventilating new Webster School at Wichita, for $6,800.

James Bays Plumbing & Heating Co., Arkansas City, Kan., heating and plumbing new high school, in that city, for $3,700.

Western Heating Co., Los Angeles, Cal., installing boiler plant in Hollywood High School, for $2,850.

Crowell & Sutton, Los Angeles, heating and ventilating Forty-second Street School, in Los Angeles, for $2,255.

J. P. Dwyer Co., Boston, Mass., heating and ventilating Noble School, in Boston, for $2,882. Other bids were: J. E. Hern Engineering Co., $3,190; The Power Heating & Ventilating Co., $3,190; Laskey & McMurrer, $3,225; J. J. Hurley & Co., $3,295; Huey Bros. Co., $3,718; Isaac Coffin Co., $3,826; and F. W. Zemier & Co., $3,896.

Wollen & Callon, Indianapolis, Ind., heating and plumbing new Masonic Home at Franklin, Ind., for $41,000.

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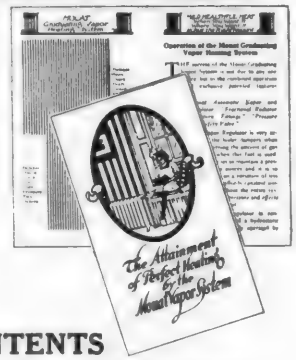

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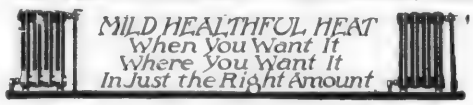

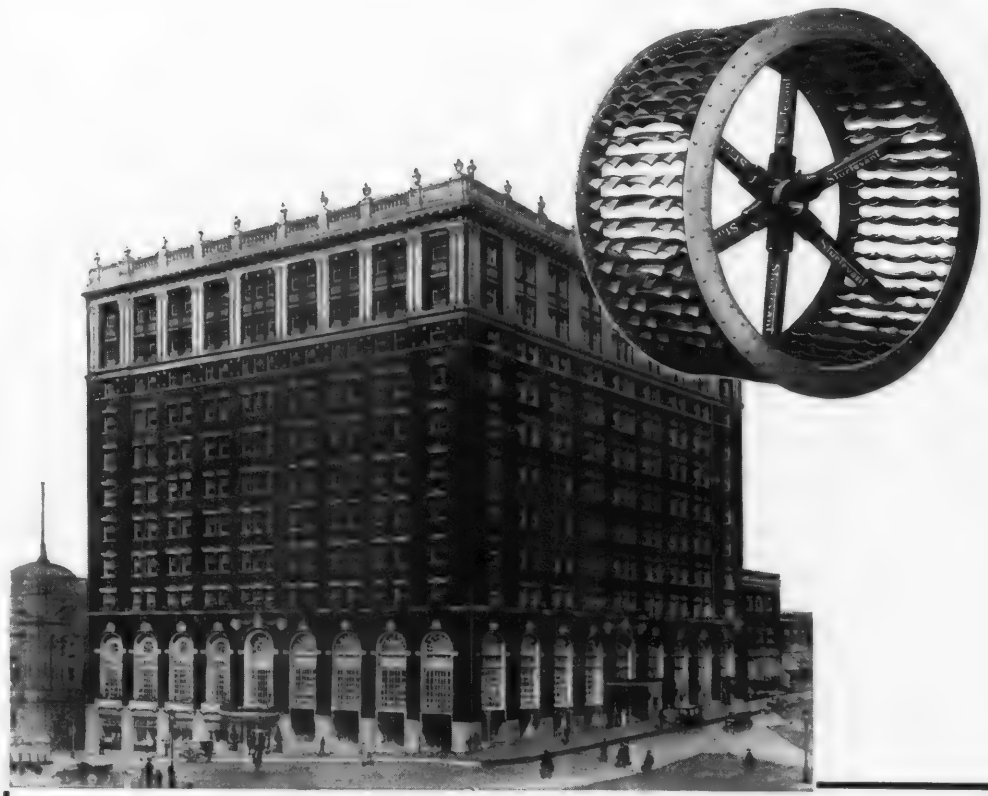

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Roades & Trayer, Logansport, Ind., heating and plumbing new $45,000 high school at Walton, Ind.

Gibson & Croner, Troy, O., heating County Infirmary Building at Troy, for $2,363. A bid for this work was submitted by the John Arpp Co., Middletown, O., amounting to $3,066.

John T. Powers Co., Brockton, Mass., heating and plumbing Franklin School at Montello, for $3,900.

Standard Plumbing Co., Spokane, Wash., heating and ventilating new school building at Davenport, for $3,613. Other bids were: Blair-Meagher Co., Spokane, $3,640; Arnold & Evans, Spokane, $3,734; M. Gebister, Spokane, $3,938; W. J. Griffith, Spokane, $4,975; P. J. Dowling, $4,173; H. A. Arnold, Spokane, $4,190; and Alfred Lebeau, Spokane, $4,650.

Port Townsend, Wash.—The following bids were received for the installation of an oil burning system in the Federal Building at Port Townsend: S. Normile Heating & Plumbing Co., Seattle, $1,076; A. H. Cox & Co., Seattle, $1,490; West Coast Heating Co., San Francisco, $1,731; T. B. Jarvis Crude Oil Burner Co., San Francisco, $1,445; Ben Olson Co., Tacoma, $1,500; Appling-Griggs Co., Tacoma, $1,173.

Mayfield & Breedlove, Madison, S. D., heating and plumbing new school building at Colman for $2,550.

John H. Kitchen Co., Kansas City, Mo., heating, ventilating and plumbing new high school building at Mystic, Ia., also heating and ventilating new high school at Unionville, Mo.

F. O. Schoedinger, Columbus, O., heating and ventilating Chemistry Building at the Ohio State University.

Elder Mercantile Co., Ottawa, Kan., heating and plumbing new high school at Gardner, Kan., for $4,100.

H. L. Hanson, Butte, Mont., remodeling the heating, ventilating and plumbing systems in the high school, for $94,640.

Collins Plumbing & Heating Co., Great Falls, Mont., heating and plumbing the new $80,000 Tribune Building, at that place.

American Foundry & Furnace Co., Joliet, Ill., heating and ventilating North Hickory and Longfellow Schools in Joliet, for $4,735.

F. P. Walsh, San Francisco, Cal., furnishing and installing boilers in the new Polytechnic High School, for $13,800.

J. J. Sullivan, Haverhill, Mass., heating City Hospital, for $5,000.

Ford & Luce, Haverhill, Mass., heating and plumbing building of the Haverhill Electric Co., for $2,200; also heating and plumbing residence of J. H. Kelso, for $2,200.

Perry E. Elliot & Co., Haverhill, Mass., heating and plumbing Nurses' Home at the City Hospital, for $3,000.

Cook & Chick Co., Oak Park, Ill., steam heating new $35,000 Masonic Temple at Euclid avenue and Harrison Street, Oak Park.

Charles Hahn, Lewiston, Idaho, heating, ventilating and plumbing new high school building in Colton, for $2,200. Other bids were: Arnold-Evans Co., Spokane, $2,600; Blair-Meagher Co., Spokane, $2,645; F. A. Peterson, Lewiston, Idaho, $2,652; and Whitter-Fisher Co., Moscow, Idaho, $2,570.

S. Normile, Seattle, Wash., heating apartment and hotel building at Fourth and Marion Streets, Seattle, for $4,600.

W. G. McPherson Co., Portland, Ore., heating and ventilating addition to the Oregon City School, for $2,000.

Baker, Wash.—Bids were received as follows for the heating and ventilating of the Court House building in Baker: O'Rourke Bros., Walla Walla, Wash., $2,198; Finnegan Bros., Portland, $2,268; Fish & Bowen, Baker, $2,200; Appling-Griggs Co., Tacoma, Wash., $2,812.

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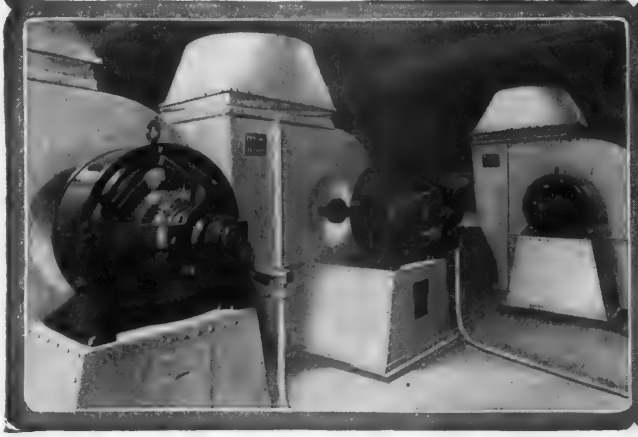

W. W. Campbell & Son, Malden, Mass., heating and ventilating new school building in that city for $6,117. The plumbing contract went to W. P. Kane, of Medford, at his bid of $1,840.

Dupar Bros., Bellingham, Wash., heating, ventilating and plumbing alterations at the Bellingham State Normal School; amount of contract, $9,948.

Business Chances.

Washington, D. C.—Sealed proposals will be received at the office of the Supervising Architect, Treasury Department, for the following-named work:

Until Sept. 27, 1915, for the construction complete, including mechanical equipment, etc., of a two-story and basement stone-faced building of 28,700 sq. ft. ground area, for the U. S. Post Office and Court House at Tulsa, Okla.

Until Sept. 28, 1915, for the extension and remodeling, including mechanical equipment, of the U. S. Post Office and Court House at Harrisburg, Pa.

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The "Kieley" Settlement, as Viewed by Each Party.

An announcement made by the Western Kieley Steam Specialty Co., Chicago, under date of July 12, 1915, states that "a writ of injunction was issued June 23, 1915, by the Circuit Court of Cook County perpetually enjoining James McAlear, Kieley & Mueller, Inc., and the Kieley Specialty Company from using the name Kieley Specialty Company, or any other corporate, co-partnership or other name or style which include the name 'Kieley' and the word 'Specialty' in any combination in any manner whatsoever.

"The appropriation of the principal part of our corporate name, as well as the issuing of circulars by the Kieley Specialty Company was the cause of considerable confusion among the trade.

"This clean-cut decision, therefore, removes this cause of confusion by requiring the prompt dissolution of the Kieley Specialty Company, Fisher Building, and more recently located at 442 North Wells Street, Chicago, as well as the spurious 'Kieley' companies of mushroom growth and origin.

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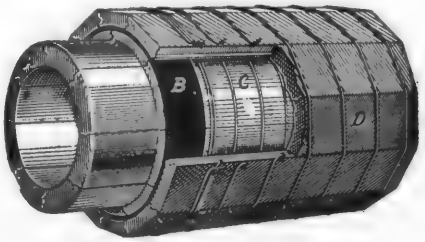

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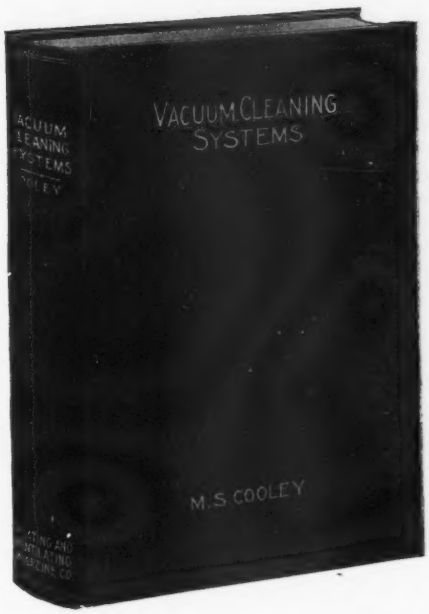

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Mechanical Engineer, Office of Supervising Architect, Treasury Department, Washington, D. C.

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1123 Broadway, New York

corporated over seventeen years ago, and doing business all over the country."

In this connection a "statement to the trade and public" has been issued by Kieley & Mueller, Inc., of Chicago, which refers to the Western Kieley Steam Specialty Company's statement and goes on to say that the notice "failed to state all the facts, and in order to prevent the trade and public from getting an erroneous impression we are attaching hereto a copy of the agreement with the signatures of all parties, so that the trade and public can see for themselves that the writ of injunction above referred to was not a clean-cut decision, but was consented to by Kieley & Mueller, Inc., as set forth in the annexed agreement. We ask you to note particularly * * * that the Western Kieley Steam Specialty Company expressly agrees that it will not in the future advertise the name Western Kieley Steam Specialty Company in any trade journal, magazine or catalogue, except only their present supply of old catalogues, or a stated number of new ones" (as outlined in the agreement).

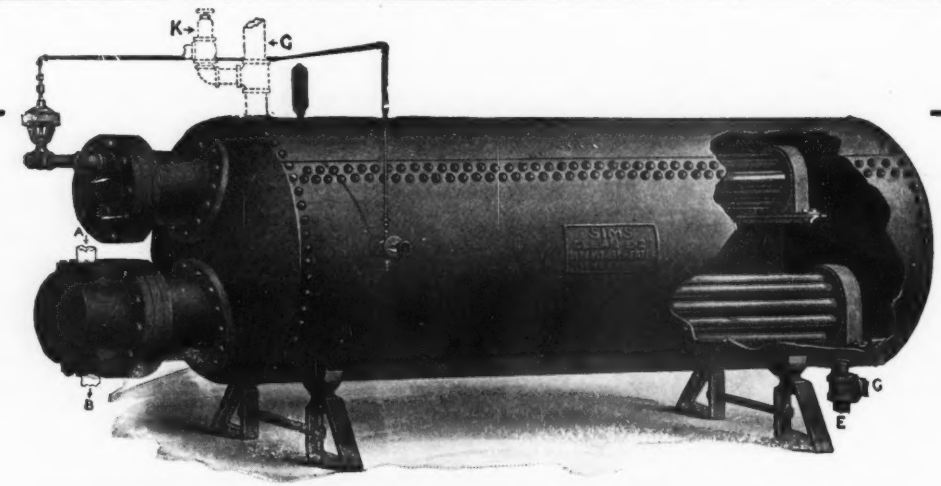
"Also note that the Boylston companies must thereafter not use our trade names and that they must dissolve their Kieley Steam Specialty Company and withdraw its prices, and that it will, on request of Kieley & Mueller, Inc., restrain any attempt by others to use in business the names Western Kieley Steam Specialty Company, Kieley Steam Specialty Company, Kieley Specialty Company, or any name having the words 'Kieley' and 'Specialty' or 'Specialties' in any combination."

The agreement is dated June 22, 1915, and the injunction decree is dated June 23, 1915.

Farnham Yardley, vice-president of Jenkins Bros., New York, was elected president of the American Supply and Machinery Manufacturers' Association at its recent annual meeting. During 1914 he was vice-president of the association. Mr. Yardley, who is a prominent figure in the heating and mill supply trade, has also the distinction of being mayor of West Orange, N. J.

Wanted.

Position Wanted by engineer and estimator on heating, ventilating and power work. Absolutely satisfactory references. At present employed; desires to change. Must be good opportunity. Address Box 17, care of Heating and Ventilating Magazine.



WHEN THE HOT WATER DEMAND RUNS HIGH

Our large experience in manufacturing heaters for laundries has developed the fact that there is not always enough exhaust steam to heat all the water to the temperature required. This is always the case with a wet-wash laundry. For a high hot water demand use the

SIMS CLEAN E-Z HEATER, TYPE D.

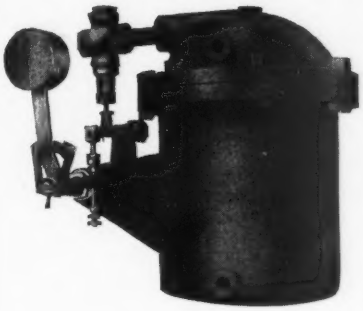
This heater is supplied with two sets of straight, seamless drawn brass tubes, the lower for exhaust steam, located in the coolest water. The upper set of tubes is for live steam direct from the boiler, controlled by a thermostat.

Our Bulletin HL-2 gives full particulars of Sims Heaters for laundries, hotels, hospitals and other service. Consultation free. All work guaranteed.

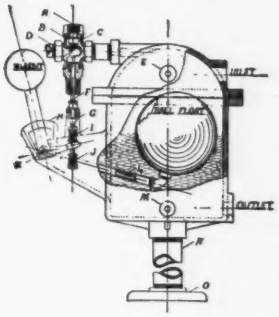
THE SIMS COMPANY **18th Street, Erie, P**

The Lytton Thermo Syphon Trap

Approved and Specified by Heating Experts



Especially designed to perform important duties in connection with the handling of condensation under the complicated operating conditions of Pressure, Vapor, and Vacuum Steam Heating Systems.



It automatically discharges all condensation direct into the boiler.
Positive in operation, irrespective of the pressure or vacuum.
Releases all air and non-condensable gases without loss of vapor.
Air relief tanks and receivers are not required with this trap.
Prevents radiators from becoming flooded or air bound.
Renders possible more heat on less boiler pressure.
Eliminates "hammering" and other nerve-wrecking noises.
Prevents burning of boilers, due to water becoming locked in system.
Assures perfect circulation and even distribution of steam.
Reduces coal consumption and labor to the minimum.
With sufficient pressure will take returns from below boiler water line.
Is installed only 3″ above water line and requires very little room.
Noiseless in operation and is easy to install.
Is heavily constructed, has no delicate parts, and is fool-proof.
Is guaranteed by us in every respect, and price is attractively low.

BULLETIN NO. 14, which will be sent upon request, fully describes the special mechanical features and refinements of this interesting device, and same should be in the possession of every Engineer, Architect, Heating Contractor, and owner of a steam heating system. We furnish full instructions and blue print for guidance in making installation and cooperate with the purchaser in every manner possible. We solicit correspondence concerning the handling of condensation from heating systems or any other class of steam using apparatus.

LYTTON MFG. CORPORATION

FRANKLIN, VIRGINIA

Manufacturers of Direct Return Traps, Steam Traps, Vacuum Traps, Lifting Traps, Thermo Syphon Traps, Reducing Valves, Blow-Off Valves.

Add to your profits

Fall begins September 23rd. Already you have closed many heating jobs and you will be called upon to figure many others.

Do not overlook your

ARCO WAND
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opportunity when you are taking measurements. If you discover your prospective customer trying to keep the house clean with brooms, dusters, and sweepers, proclaim yourself at once as a vacuum cleaner contractor also.

Attach a vacuum cleaner addenda bid to your heating estimate. Talk vacuum cleaning. Talk the

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Contract to install the machine as well as the piping.

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AMERICAN RADIATOR COMPANY

Public Showrooms at Chicago, New York, Boston, Worcester, Providence, Philadelphia, Washington, Baltimore, Rochester, Buffalo, Pittsburgh, Cleveland, Cincinnati, Detroit, Atlanta, Birmingham, New Orleans, Indianapolis, Milwaukee, Omaha, Minneapolis, St. Paul, St. Louis, Kansas City, Denver, Seattle, Portland, Spokane, Los Angeles, San Francisco, Toronto, Brantford (Ont.), London, Paris, Brussels, Berlin, Cologne, Milan, Vienna